

NORTHERN WATERS:

CAPTAIN ROALD AMUNDSEN'S OCEANOGRAPHIC
OBSERVATIONS IN THE ARCTIC SEAS IN 1901.

WITH

A DISCUSSION OF THE ORIGIN OF THE BOTTOM-
WATERS OF THE NORTHERN SEAS.

BY

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(WITH 11 PLATES.)

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To

Roald Amundsen

*the careful planner and happy leader of Arctic enter-
prise, a tribute*

from

the author.

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I. Introductory Remarks.

After having bought his now famous little vessel, the *Gjøa*, Captain Roald Amundsen wished to make a preparatory cruise in the Arctic seas, in 1901, in order to try the vessel, and to gain experience with her in the ice, before starting on the quest for the Magnetic North Pole and the North West Passage. To pay the expences of this first cruise, Amundsen was to catch seals in the Barents Sea, the Spitsbergen Seas, and the East Greenland Sea; but at the same time he was anxious to make use of the opportunity for scientific work; I proposed that he should make oceanographic observations. If carefully carried out with modern instruments I knew they would be of great scientific value, especially in the sea north of Jan Mayen, between Spitsbergen and Greenland, where hitherto very few trustworthy investigations have been made. If Amundsen should succeed in his plan of going through the ice, to the east coast of Greenland, he would be able to make a hydrographical section across the East Greenland Polar Current, which would be of the highest value, and would probably solve problems of importance in understanding the Physical Oceanography of the whole Norwegian Sea. Captain Amundsen accepted the proposal with enthusiasm, and he then got the following instrumental equipment: 1 insulated Pettersson-Nansen Water-Bottle, 1 smaller water-bottle of my construction (which was not insulated but which closed tightly, and gave perfect water-samples), 2 Nansen Deep-Sea-Thermometers (from Richter, Berlin), for the insulated water-bottle, 1 Reversing Thermometer from Richter, Berlin, 2 Negretti-Zambra Reversing Thermometers, a few lenses for reading off the thermometers (to avoid parallax), several ordinary thermometers (from the meteorological Office, Christiania), a few Nansen closing Plankton-nets of different sizes, and several thousand bottles for holding the water- and plankton-samples. Captain Amundsen had a very good hand-winch with 2000 metres steel line specially constructed,

and he also had a meter-wheel of my construction (the larger size of those now delivered through the International Central Laboratory of Christiania).

He also constructed a simple water-bottle for taking water-samples and temperatures down to moderate depths, while the vessel was sailing.

He received instruction in taking all kinds of oceanographical observations, and both he and his assistant, Sergeant Ristvedt (also a member of his present expedition 'through the North West Passage), had some practice in taking of water-temperatures and water-samples etc. in the laboratory and on the ice in Christiania Fjord.

Thus better equipped for physical oceanographic research than any arctic expedition before, Captain Amundsen started from Tromsø on April 22, 1901. He returned to Tromsø again on September 4, 1901. with a splendid collection of observations, 2128 water-samples, 627 plankton-samples, etc. He had also thrown out 382 bottles (with post cards) for determining the drift. The post-cards were addressed to me, and I have received a good many which will be mentioned later.

The ice-conditions had been unfavourable, so that Amundsen had not been able to penetrate the ice and reach the East Coast of Greenland. He had therefore not succeeded in taking a complete transverse section of the East Greenland Polar Current and underlying waters; but still, the series of observations which he succeeded in taking from this region are, as we shall see below, of fundamental importance in understanding the origin of the »bottom-water« of the Norwegian Sea, which forms more than two thirds of the quantity of water filling this basin.

Amundsen was, however, so keen on completing the task he had set himself, *viz.* of taking a complete section of the Greenland Polar Current, that in his first telegram from Tromsø, he asked me whether he might keep the instruments and oceanographical equipment, on board the vessel, as he wished to go out again the following year to make the complete section of the Polar Current. It was only on my advice that he gave up this plan. I thought it was still more important for him not to delay by one year the preparation for his expedition to the Magnetic North Pole.

The plankton-samples brought back by Amundsen have been examined by Professor H. H. Gran, and will be described by him in a special paper.

II. Instruments.

After observations at the first five stations having been taken with the Pettersson-Nansen insulated Water-Bottle this instrument was lost by an accident (the steel-line broke), and all deep-sea temperatures after that time were therefore taken with the Richter or Negretti and Zambra Reversing Thermometers.

Richter Reversing Thermometer No. 113.

This instrument was one of the first two reversing thermometers which were made at my suggestion by Richter in Berlin, and which he sent me for my approval in March 1901. After having tested it I sent it to Amundsen. The thermometer was made of Jena glass 16 III, and had a small thermometer enclosed inside the outer protecting glass-tube by which the temperature of the broken-off mercury could easily be determined simultaneously with the reading off. It is the same improvement which has since been introduced on all reversing thermometers from Richter. The scale was divided into fifths of degrees. The instrument had the disadvantage, that if it was not reversed somewhat roughly with a shock, the mercury would not break off. The reversing apparatus had therefore to be specially arranged for this purpose.

The thermometer No. 113 was tested at *Physikalisch-Technische Reichsanstalt* in Charlottenburg, Berlin, in March 1901 (where it received the number PTR 15657) and its zero-correction was determined again (four independent determinations giving uniform results) on September 13, 1901, immediately after the return from the expedition, by my assistant Mr. Jakob Schetelig at our laboratory in Christiania.

Corrections of Richter Reversing Thermometer No. 113.

Scale.	Corrections.	
	March 1901 Char- lottenburg.	September 1901 Christiania.
— 2°5' C.	+ 0°06' C.	*
0°0' "	+ 0°08' "	+ 0°056' C.
+ 10°0' "	+ 0°06' "	
+ 20°9' "	+ 0°04' "	

+ indicates that the error has to be added to the observed temperature in order to find the correct temperature. By several determinations it was also found that if the mercury be broken off at temperatures about zero, the correction due to the difference of temperature at which it is read off, is about 0.0098° C. for each degree the broken-off mercury is cooled or heated.

Amundsen made one observation of the zero-correction of the instrument during the voyage, on July 1, 1901, but as he himself remarks it is of no value as it was too difficult to make the mercury break off. As the thermometer was made of Jena normal glass 16III it may be assumed that it has altered its corrections fairly gradually during the time of the voyage, and as the instruments were, as a rule, exposed to lower temperatures than in the laboratory it seems probable that the corrections were if anything somewhat smaller than as indicated above. It may therefore be assumed that the zero-correction during the voyage was very nearly $+0.06^{\circ}$ C.

Negretti and Zambra Reversing Thermometers Nos. 72012 and 72620.

These thermometers were several years old, and were of the ordinary type delivered by Negretti and Zambra. They were made of ordinary English glass, and the scales were divided into whole degrees. The graduation was rather rough, so that it was somewhat difficult to read off the temperature accurately, with a reading lens, or even with a reading microscope.

The following determinations of the zero-correction were made.

Zero-corrections.

Date.	N. Z. No. 72012.	N. Z. No. 72620.
March, 1901, Christiania	— 0.12° C.	— 0.16° C.
July, 1901, Gjøa	— 0.135 "	— 0.14 "
September 5, 1901, Gjøa, Tromsø	— 0.20 "	— 0.20 "
September 12, 1901, Christiania .	— 0.136 "	
September 13, 1901, Christiania .	— 0.16 "	— 0.12 "

The mercury broken off at zero expanded by an amount equal to about 0.01° C. of the scale, for each degree it was heated.

The zero corrections determined by Mr. Jakob Schetelig at the laboratory in Christiania before and after the voyage were taken with a reading microscope, and were consequently fairly accurate. In March, 1901, at the same time as Schetelig, Amundsen also determined the zero-correction of the same thermometers with one of the ordinary lenses, such as he used on the voyage, and it then appeared that it was very easy to get a somewhat too great correction, as he several times obtained -0.20 for No. 72620, whilst it should have been -0.16 . This is evidently due to the very thick and coarse division-marks of the thermometer scale.¹

It is a striking fact that the temperatures taken during the voyage with these thermometers are nearly always lower than those taken simultaneously with the Richter Reversing Thermometer No. 113. The difference is strangely enough very uniform, about 0.10°C . (cf. the Tables of Observations). This proves that Amundsen has evidently read of his thermometers with great care, and by a very uniform method. It does not seem probable that these old Negretti and Zambra thermometers should have altered their error so much as to indicate during the voyage on the average about 0.1°C . lower than they did both in March, before the voyage, and in September, after the voyage; and besides, this would not be in accord with the zero-corrections taken during the voyage. But it does not seem more probable that the Richter thermometer, made of Jena glass No. 16III, should suddenly have altered its error during the voyage, as much as to indicate 0.1°C . higher than it did both before and after. It seems more probable that some fairly uniform error has been made during the reading off of the Negretti and Zambra thermometers, perhaps some error of parallax *e. g.* the axis of the reading lens may have been placed not perfectly perpendicular on the stem of the thermometers; and as the stem is very thick, only a slight error of parallax is sufficient to amount to 0.1°C . in the reading.

In order to determine the temperature of the broken off mercury, at the moment the thermometers were read, they were always placed in a waterbath for some time before the reading was taken. The temperature of the water-bath was taken simultaneously, and recorded in the journal. The reading were subsequently corrected accordingly.

Nansen Deep-Sea Thermometers. Richter Nos. 109 and 110.

These thermometers were of the same type as now generally made by Richter for the Pettersson-Nansen Water-Bottle. They were made of

¹ The determinations of the zero-corrections made on board the *Gjøa* on September 5, 1901, in Tromsø, are therefore less trustworthy than those made at Christiania.

Jena Glass No. 59^{III}, and protected by an outer strong glass tube. The stem was filled with an inert gas, nitrogen or carbonic acid, in order to prevent the division of the mercury thread which was found very troublesome during the voyage with the Michael Sars, in 1900. This gas in the stem proved a great improvement. The scale ranged from -3 to $+8^{\circ}$ C. in No. 110, and from -3 to about 10° C. in No. 109. Both scales were divided into tenths of degrees centigrade. A degree had on No. 110 a length of 1 cm. but was in No. 109 somewhat shorter.

Both instruments were tested at the *Charlottenburg Reichsanstalt* in March, 1901, and were marked PTR 15655 (for 109) and PTR 15656 (for No. 110).

The following determinations of the corrections were made.

Corrections.

Scale.	Deep-Sea Thermometer No. 109.					Deep-Sea Thermom. No. 110.
	March 14, 1901 Charlottenb.	July 1, 1901 Gjøa.	Septb. 5, 1901 Gjøa.	Septb. 12, 1901 Christiania.	Septb. 13, 1901 Christiania.	March 14, 1901 Charlottenb.
-3° C.	$+ 0.06^{\circ}$ C.					$+ 0.01$
0 "	$+ 0.05$ "	$+ 0.13^{\circ}$ C.	$+ 0.12^{\circ}$ C.	$+ 0.105^{\circ}$ C.	$+ 0.10^{\circ}$ C.	0.00
$+ 5$ "	$+ 0.07$ "					$+ 0.02$
$+ 8$ "						$+ 0.02$
$+ 10$ "	$+ 0.07$ "					

Thermometer No. 110 was lost with the Pettersson-Nansen Water-Bottle in May 1901.

It seems somewhat puzzling that No. 109 should have indicated so much lower during the voyage than it did before and afterwards. Amundsen says in his journal, that on Juli 1, a piece of freshwater ice drifting in the sea, was used for the zero-determination. It may seem doubtful whether this ice has been sufficiently pure; but according to zero-determinations made with other thermometers in the same ice, simultaneously, it does not seem probable that the ice can have been impure enough to have caused any significant error. On the other hand it seems more probable that Amundsen has got fairly pure ice in Tromsø for his determination on September 5, 1901.

Thermometer No. 638.

This was a thermometer which Amundsen had from the Meteorological Institut at Christiania for taking surface-temperatures. Its zero-

correction was: ± 0.0 in March (Christiania), on July 1, and on September 5, 1901.

This instrument was generally used for the surface-temperatures. Three meteorological thermometers, Nos. 0, 35 and 39, were also occasionally used for the sea-surface. The corrections of these instruments were also insignificant.

The Amundsen Water-Bottle.

This instrument was constructed by Amundsen for taking water-samples and temperatures from the upper water-strata, while the vessel was under sail. It was a glass-bottle with fairly wide opening and was closed by a lid made of brass plate with a sheet of india rubber on its underside; the lid was pressed down by a strong spiral spring. The glass bottle was protected outside by a hempen network, and it had a heavy lead attached underneath. When the bottle was thrown out the line was kept quite slack while the bottle was sinking; when it had sunk to the desired depth, a sudden pull in the line opened the lid, the bottle was filled and hauled up. The temperature was then at once taken by an inserted thermometer, and a water-sample stored. It does not, however, seem probable that the lid has been able to close so perfectly tight as to prevent water from being pressed in during the sinking of the bottle, and the temperatures and samples obtained in this manner from the water-strata down to 15, and sometimes even 25 metres, cannot therefore be considered as perfectly trustworthy. They are, however, of value, in as much as they at any rate give some information as to the conditions of the water-strata underlying the surface-layer, which is of special importance in the arctic seas, where ice is melting on the surface.

On cold days when the sea-water was cooled to its freezing-point (or even perhaps slightly supercooled) near the sea-surface, the water-samples taken by this small water-bottle, have evidently given erroneous results. It is seen in Table I, that on April 30, on May 3—May 9, and May 23—May 28 most samples taken from 5 and 10 metres or deeper, give remarkably high salinities, some even above 36 ‰. The explanation obviously is that as soon as the cold sea-water, cooled to its freezing-point or perhaps even slightly supercooled, has been enclosed in the small cold water-bottle it has begun to form ice on the glass-walls, and the water-sample taken after the bottle came on deck again, has got a much too high salinity. It seems somewhat surprising that the salinity thus resulting has in many cases become rather uniform, (*e. g.* about 35.26 ‰). The explanation may be that the taking of the sample has required about the same time in the

different cases, and that consequently about the same quantity of ice may have been formed on the bottle. It is also a striking coincidence that the salinities obtained are especially high on days with very low air-temperature (*e. g.* May 3, 6, 26—28). The glass-bottle may probably have been very cold, when it was sent down, and the cold glass with frozen hempen network outside, may have intensified iceformation inside the bottle. In some cases the sample taken from one depth (*e. g.* 5 metres) gives a very high salinity, whilst the samples taken from other depths give more probable salinities. The latter may have been taken after the former, and in that case the bottle by being filled with water once before, may then have become heated to the freezing point of the sea-water; with a smaller formation of ice subsequently as the result.

This formation of ice has, however, in several cases, obviously had the opposite effect, and produced samples which have given much too low salinities. The explanation is evidently that there have been numerous small ice-needles floating in the sea-water, which have got into the water-samples. We thus see that water-samples taken on such cold days, with the sea-water at about its freezing-point, are not trustworthy, unless special precautions be taken to avoid errors caused by the formation of ice on the water-bottles. Even samples taken with the bucket on such days, may give erroneous results from the same reason; but, as the water-bucket would hold a much greater quantity of water, and the hauling up would take less time, the effect of the formation of ice will be much less in this case.

The Water-Samples.

The water-samples were taken very carefully especially from the deeper strata. The water-bottle was wiped outside and around the tap in order to prevent possible drops of surface-water from getting in with the water-sample when run out into the glass-bottle. The glass-bottles, used for surface-samples, would hold about 100 cubic-centimetres; whilst all samples from the Stations were taken in bottles holding 150 cubic-centimetres. They were closed by cork-stoppers which had been carefully selected. The bottles had been washed out in hot water for several days at the laboratory, before the expedition started. When the samples had been taken, the cork-stoppers were driven down as hard as possible into the necks of the bottles, which with the corkstoppers were dipped into melted paraffine-wax, and tied over with fairly airtight paper. To judge from the determinations of the chlorine, especially of the samples from the Stations, it seems as if the cork-stoppers have on the whole held very

tight, and the evaporation has in fact been insignificant, except in a very few cases.

The water-samples were examined by titration (Mohr) at my laboratory in the University of Christiania, as soon as possible after they were received. The titrations were carefully made by Mr. Ingolf Leivestad; they were frequently controled by my assistant Mr. Jakob Schetelig, whose determinations with the Hydrometer of Total Immersion agreed on the whole well with Leivestad's results. Mr. Leivestad controled every ten titrations by means of Standard Water, determined by Mr. Schetelig with Hydrometer of Total Immersion.

Mr. Schetelig gives the following information about the Standard Water and Leivestads' determinations:

"The Standard-Waters were obtained by mixing several samples of sea-water in a big glass-bottle, which was afterwards filled into green selters-bottles with patent india-rubber stoppers; 8 or 10 bottles were in this manner obtained of each water. Standard Waters Nos. I, II, and III were used by Leivestad for about 3000 titrations. The values for the salinity of the Standard Waters, were exclusively based on determinations of the specific gravity by means of the Hydrometer of Total Immersion. The following final values were obtained as the means of a series of determinations.

			σ_0	S ‰	Cl. ‰
Sept. 9, 1901	Standard-water	No. I . . .	27.71	34.49	19.09
Nov. 11, 1901	—	" II . . .	28.00	34.85	19.29
Jan. 1, 1902	—	" III . . .	28.02	34.87	19.30

"The accuracy of the value of σ_0 is probably inside a limit of ± 0.005 (i. e. inside ± 0.000005 of specific gravity).

"Standard-Water No. I has unfortunately a lower salinity than a Standard-Water ought to have, and this water was used for the titration of all samples of deep water from Amundsen's Stations. The same water (No. I) was also used for the titration of Makaroff's samples (see below).

"In order to use Mr. Knudsen's Titration-Tables a series of aid-tables had to be computed.

"If by the use of this Standard-Water No. I, with the low salinity, any error at all has been introduced into the determinations, this error must be constant for all of them, and may be computed."

"By comparing the results of the titrations I have, however, come to the conclusion, that there cannot be any great error. The values obtained by titration and by the Hydrometer of Total Immersion agree very

well, where both kinds of determinations have been made (Makaroff's samples, Amundsen's samples in selters-bottles, many samples of deep-water from the cruise of the Michael Sars 1900, and the samples from Wollebæk's Stat. II)."

Jakob Schetelig.

Two series of water-samples were taken by Amundsen in green selters-bottles with patent india-rubber stoppers, which close perfectly tightly. The bottles were old and had been washed for days in hot water. They would hold about 600 cubic-centimetres of water. The samples were examined by Mr. Jakob Schetelig with the Hydrometer of Total Immersion and by Mr. I. Leivestad by titration. I give below the results as computed from Martin Knudsens Tables.

Station.	Date and Locality.	Depth in metres.	Schetelig by Hydrom. Tot. Imm.		Leivestad by Titration.		Difference in S ‰
			σ_0	S ‰	Cl. ‰	S ‰	
6a	May 9, 1901 69° 32' N. 45° 37' E.	1	27.63	34.38	19.04	34.40	+ 0.04
		5	.65	.42	.045	.41	— .01
		10			.04	.40	
		20	.63	.38	.04	.40	+ .02
		30	.62	.37	.045	.41	+ .03
		40	.62	.37	.055	.42	+ .05
							+ 0.026
22a	July 11, 1901 74° 26' N. 6° 24' W.	1	26.72	33.26	18.39	33.22	— 0.04
		5	.77	.31	.44	.31	.00
		10	27.03	.64	.62	.64	.00
		20	.44	34.14	.90	34.14	.00
		30	.73	.51	19.10	.51	.00
		40	.91	.73	.22	.72	— .01
							— 0.008

We see that the values obtained by the two methods of determination of the samples from the sea east of Greenland in 74° 26' N. Lat. agree much better than those of the samples from the Barents Sea. Provided that the titrations have given fairly accurate results, this seems to indicate that in the water from the Barents Sea there has been a comparatively great amount of chlorine, giving a salinity which is on the average about 0.03 ‰ too high; whilst in the sea east of Greenland the permillage of Chlorine has been about normal, perhaps slightly too small. The explanation may be, that on July 11, 1901, ice, exposed to low temperatures during the winter, had been melting at the surface in the region where

the samples were taken; whilst on May 9, in the Barents Sea, very little ice had melted, though much ice had been formed and exposed to low temperatures, in this region, during the winter.¹ It is also a striking coincidence that in Makaroff's samples from the upper water-strata of the sea near Franz Josef Land and between these islands and Novaya Zemlya (see below), the chlorine values also give higher salinities than the specific gravities, and the discrepancy is greater than might be explained by errors of observation. It is also striking that the determinations of Makaroff's samples from the deeper waters, from 300 metres Stat. 77, and from 100 and 200 metres Stat. 82, agree very well, the titrations giving slightly too low salinities. The values obtained for the samples from 250 and 300 metres Stat. 83 agree also fairly well, but those for the sample from 350 metres show a greater discrepancy. The determinations by titration and by Hydrometer of Total Immersion of the samples from Wollebæk's Stat. II (see below) agree also fairly well, the discrepancy being between $+ 0.01$ ‰ near the surface (10 metres) and $- 0.015$ ‰ near the bottom (120 metres). We see that in this region of the sea, the disagreements go on the whole in the same direction, the chlorine gives comparatively high values of salinity near the surface, but comparatively lower salinities for deeper water.

The Accuracy of Determinations of Temperature and Salinity in the Vertical Series at the Stations.

The temperatures taken with the Richter Reversing Thermometer No. 113, are probably correct to within a few hundredths of a degree Centigrade. The instrument was made of very good glass (Jena Glass 59^{III}, see above), was divided neatly, by very thin and distinct marks, into fifths of a degree centigrade, and the indications could easily be read off by means of a specially arranged lens, with an accuracy of ± 0.01 °C. And by means of the enclosed small thermometer the temperature of the broken off mercury was always determined at the moment of reading.

¹ By some rough experiments made at the Central Laboratory for the International Study of the Sea, at Christiania, we have found that where ice is formed in sea-water no appreciable alteration is produced in the relation between the quantity of chlorine and the specific gravity of the sea-water, although the salinity of the latter be much increased. The recent investigations of Dr. W. Ringer: „Ueber die Veränderungen in der Zusammensetzung des Meereswassersalzes beim Ausfrieren“ (No. III: Verhandelingen uit het Rijksinstituut voor het onderzoek der Zee, 1906, Helder) prove that it is only after the ice is exposed to temperatures below $- 8^{\circ}0$ C. that the relation between the chlorides and the other salts (especially sulphates) in the brine of the ice, is appreciably altered.

The temperatures taken with the Negretti and Zambra Reversing Thermometers are not so accurate. The graduation of the scale of these instruments is as usual very rough, and their indications could hardly be read off with greater accuracy than $\pm 0.05^{\circ}$ C. with the lenses. But in the final values there may be still greater errors, owing to possible variations of the instrumental errors etc.

The accidental errors of the salinity determinations as obtained by titration are, as a rule, hardly more than ± 0.01 ‰. But, as mentioned above, there might in addition be a small constant error, owing to the Standard Water used, which is, however, insignificant. In another way there may, however, be a more significant error in the salinities. For a work which Mr. Helland-Hansen and the present writer are now preparing on the "Physical Oceanography of the Norwegian Sea", we have made very accurate determinations of the Specific Gravity and the Chlorine of the cold Bottom-Water of the Norwegian Sea, and it appears that the salinities computed by Knudsen's Tables from the chlorine may for this kind of water¹ be between 0.01 and 0.03 ‰ lower than those obtained from the specific gravity. It seems therefore probable that the salinities and densities (σ_t) given in Table II, for Amundsen's cold deep water may be somewhat too low, owing to the deficiency of chlorine in this water; *e. g.* in the case of the salinities from 1700 and 2000 metres at Stat. 16, they may probably have been about 34.92 ‰ instead of 34.90 or 34.89 ‰, and the density (σ_t) may probably have been 28.12 instead of 28.10.

In some cases the salinities obtained for the samples of deep water are obviously too high. This is, however, not due to inaccuracies of the determinations; the cork-stoppers of the glass-bottles have probably not been perfectly tight and some slight evaporation has occurred during the time between the taking of the sample and the titration. As examples may be mentioned the samples from 150 and 250 metres at Station 20 (July 4, 1901). These samples gave salinities of 34.95 and 35.05 ‰, whilst the real value was between 34.91 and 34.92 ‰ to judge from the density of the water-strata above and below these depths. The salinities obtained give densities (σ_t) of 28.13 and 28.20, which would make the water sink very rapidly; and further, no salinities of such high values were observed in any depth at neighbouring stations.

¹ Cf. B. Helland-Hansen and F. Nansen, *The Physical Oceanography of the Norwegian Sea, Report on Norwegian Fishery- and Marine Investigations*, vol. II, No. 2.

It has been pointed out above that water-samples taken from the surface strata on very cold days, especially with the Amundsen Water-Bottle, may give much too high salinities owing to formation of ice on the water-bottle, or they may give too low salinities owing to ice-needles floating in the water.

The results of Amundsen's observations are given in Table I and II, at the end of this paper. For further information the reader is referred to the explanations of these tables.

III. Distribution of Temperature, Salinity, and Density on the Sea Surface.

Captain Amundsen's numerous surface observations give most valuable information about the distribution of Temperature, Salinity, and Density on the surface of the Barents Sea and the Northern Norwegian Sea in the summer months of 1901. It is very fortunate that at the same time the Captains of the three sealing vessels the *Capella* (Capt. Støkken), the *Jasai*, and the *Hvidfisken* also took surface observations (temperature and water-samples) for the Bureau of the Norwegian Fishery- and Marine-Investigations under Dr. J. Hjorts leadership. Mr. Helland-Hansen who arranged the taking of these valuable observations, has kindly let me have the results for introduction here in the chart Pl. I.

In the months of May, June, and July, 1901, Dr. Hjort, with the "Michael Sars", took many stations between Northern Norway and Spitsbergen. The surface observations from these stations have also been here introduced in the chart, Pl. I.

Finally Dr. N. Knipowitsch made in July, 1901, a cruise in the Barents Sea with the "Andrei Perwoswanny" (see the chart, Pl. I).

The whole of the material thus available gives an unusually full account of the distribution of surface-temperatures and salinities in these months.

The isohalines have been drawn chiefly in accordance with the observations made in June, and July 1901. As the surface-temperatures vary rapidly with the season, no isotherms have been drawn.

If Amundsen's surface-observations, made at different times in the same region, be compared with each other, and if his observations be compared with those made by the other expeditions in the same region, it is seen that at most places, both in the Barents Sea, in the seas south of Bear Island, west of Spitsbergen, and also north of Jan Mayen, the observations taken early in the season give as a rule lower temperatures and higher salinities than those taken later. This is most striking in the case of the Barents Sea, where in April and May Amundsen found surface-salinities approaching 34.9 ‰, whilst later in the season the surface-salinities in the same region often sink much below 34.0 ‰.

In the first days of June there were surface-salinities of about 34.8‰ in the region of Amundsen's Stations 11 and 12, whilst only a month later the salinities in the same region had, according to the observations of Capt. Støkken of the *Capella*, sunk to about 34.52 , 34.01 , and 33.52‰ .

On August 1st, 1901, *Capella* also crossed Amundsen's route, and where the latter found salinities about 34.52‰ , on June 5, 1901, there was 33.37‰ then, two months later. In July, 1901, Dr. Knipowitsch also crossed Amundsen's route at several places (see Pl. I), and he everywhere found much lower surface salinities than the latter found in April, May, and the beginning of June. *E. g.* in about $74^{\circ}30'$ N. Lat. and $33^{\circ}30'$ E. Long., Amundsen found, on June 6, 1901, about 0.0°C. and 34.56‰ , whilst Knipowitsch a little more than a month later found about 1°C. and below 34.0‰ ¹. And near 74° N. Lat. and 40° E. Long. Amundsen found on June 5, 1901, — 0.8°C. and 34.44‰ , whilst Knipowitsch found in July about 1°C. and below 33.0‰ , etc.

In the sea west of Spitsbergen there are similar although much smaller differences between the observations of the *Jasai* and the *Hvidfisken* in June and those of Amundsen in July and August.

In the sea north of Jan Mayen, in the region of Amundsen's Stats. 13—23, similar and very prominent changes occurred during June and July, 1901, as is seen if Amundsen's observations from the end of June be compared with those he took later in the same region.

South of Bear Island the conditions seem to be rather complicated and to change rapidly. In June, 1901, Amundsen there found temperatures about or below zero, and salinities between 34.62 and 34.94‰ , whilst Dr. Hjort, with the *Michael Sars*, a little more than a month later, found in the same region temperatures between 0.7 and 2.7°C. , and salinities between 34.52 and 34.69‰ .

The explanation of this general reduction of salinity is probably that at the end of the winter the surface salinity of these cold regions of the sea has, as a rule, attained its maximum, owing to the formation of ice at the surface, in the same region during the winter. During the summer this ice is again melted, and the surface-salinity accordingly reduced.

It is also seen that the density of the sea surface is, in these cold regions, very much higher in the beginning of the summer, than later, not only owing to the lower temperature but also as a result of the higher salinity. And whilst, at the end of the winter, the cold surface-water of the ice-forming region has, as a rule, a higher density than that of the

¹ According to Knipowitsch's section, *Ann. Hydr. u. Marit. Meteor.* 1905, Pl. 6, Fig. 2.

Atlantic Current¹, this relation is altered during the summer, and the former surface-water becomes often much lighter than the latter, and has consequently a tendency to spread out over it. When Amundsen crossed the Atlantic Current (Gulf Stream) west of Bear Island, on June 14—15, 1901, the surface density (σ_t) was to a great extent between 27·80 and 27·90, whilst further west near the ice east of Greenland the surface density in June sank frequently below 27·50, and 27·40, and later even much lower.

If the observations in these regions be not fairly simultaneous, it is, therefore, very difficult to draw the isohalines, and it will necessarily become a matter of judgement which observations ought to carry most weight. It seems probable, however, that the isohalines of Pl. I, on the whole, give a fairly correct idea of the horizontal distribution of the salinity at the surface for the end of June and the beginning of July, 1901.

The isohalines of 35·1, 35·0, 34·9, and 34·8 ‰ show the course of the Atlantic Current, or Gulf Stream, in this region. The waters with comparatively high salinity extend far westwards in the region east and north-east of Jan Mayen. This seems to be a very general feature occurring in most years, according to the observations made with the Michael Sars and others. But in the latitude of 73° N., or between 72 and 73° N., water with salinities below 34·8 and 34·7 ‰, and with comparatively low temperatures, extends eastwards to about 10° E. Long. where, however, a narrow branch of Atlantic water with comparatively high salinity and temperature extends northwards and follows almost exactly the edge of the continental shelf, west of Bear Island. It ends as a very narrow tongue west of Prince Charles Forland, off the Spitsbergen Coast.

This Atlantic water seems to have a tendency to send off a branch of water with salinity above 34·8 ‰ westwards between 74 and 77° N. Lat., and to perform a partially cyclonic movement in this region, which, however, is not very clearly demonstrated by the observations in June and July, when this movement is obviously much altered; but it is probably more prominent, even on the surface, earlier in the season and at the end of the winter² (see also the map of temperature and salinity at 50 metres, Pl. V).

¹ Cf. for instance Amundsen's surface densities (σ_t) in the Barents Sea, in April and May, 1901, which were very frequently about or even above 28·00 (see Table I, σ_t), and considerably higher than those of the Atlantic current north of Norway at the same time.

² This is demonstrated by the observations which will be published in the Memoir by Helland-Hansen and the present writer, "On the Physical Oceanography of the Norwegian Sea", *Report on Norwegian Fishery- and Marine Investigations*, Vol. II, No. 2.

The course of the North Cape Current, running into the Barents Sea, is to some extent indicated by the isohalines of 34·8 and 34·9 ‰. Near to the northern Norwegian coast comparatively warm coastwater with lower salinity runs eastwards into the southern and southeastern parts of the Barents Sea, but farther north a very narrow branch of warm water with salinity above 34·8 and 34·9 ‰ extends eastwards and is bent in a curve towards the northeast, corresponding in shape very markedly with the configuration of the bottom (*cf.* Fig. 1, p. 24). The existence and exact position of this branch is proved by the observations of Amundsen, the *Capella* (both in July and August, 1901), and Knipowitsch, which all of them agree remarkably well, with the exception that Amundsen's observations prove that this branch with surface salinities above 34·8 and 34·9 ‰ extended farther north (towards 75° N. Lat.) on June 5, 1901, than later in July, when Knipowitsch, in his northern Section¹, found surface salinities below 34·0 ‰ in the same region, although there was a very marked indication of the same branch in deeper strata (at 100 metres)¹. This saline water is evidently stopped in its eastward course near Longitude 35° E. by the bank between 72° and 73°, with depths less than 250 metres² and is forced in a northerly direction, towards a submarine valley or channel in the bank to the north, in about 74° N. Lat. and 35° E. Long. (Fig. 1, p. 24). The soundings in these regions are not sufficiently accurate, and too scattered to allow the isobaths to be drawn with certainty; it is therefore uncertain whether there may possibly be a deeper channel traversing the bank at this place. All observations from later years seem to indicate that at this particular place there is a maximum in the salinities (see Pl. III & IV). It is uncertain, whether a narrow branch is possibly sent off eastwards towards Amundsen's Stat. 11, following the southern slope of the channel which possibly runs in this direction. As, however, there are very few soundings in this region the existence and form of this channel is uncertain.

The isohaline of 34·4 ‰ seems to indicate that there may possibly be a tendency towards a kind of cyclonic movement in the sea east of Bear Island where, according to Amundsen's observations, a tongue of water with salinity below 34·0 ‰ extends southeastwards.

Knipowitsch's observations, along his northern section, as well as those of the *Capella*, indicate that in July, 1901, a broad tongue of water, with

¹ Knipowitsch, *loc. cit.* Pl. 6, Fig. 5.

² See Nansen, *Oceanography of N. Polar Basin, Norw. North Polar Exp. 1893—96, Scientific Results*, vol. III, No. 9, Pl. III.

salinities below $34^{\circ}0$ and $33^{\circ}0/00$, extended far southwards along the meridian of 40° and 42° E. Long., whilst a broad branch with salinities above $34^{\circ}0/00$ extended northwards off the coast of Novaya Zemlya, and even towards Franz Josef Land, where Capt. Stökken (of the *Capella*) found salinities of $34^{\circ}59$ and $34^{\circ}61/00$, on July 13, 1901. The form of the isohaline of $34^{\circ}0/00$ evidently indicates roughly the course of the current in this region, and here also, there seems to be a tendency towards a greater cyclonic movement, with water flowing eastwards in the region north of the Russian coast, northwards along the coast of Novaya Zemlya, westwards, south and southwest of Franz Josef Land, and a southward movement of colder and less saline water along the meridian of 40° E., on the eastern side of the bank in 75° N. Lat.¹

Southeast of Bear Island Amundsen's observations show two patches of water with salinities above $35^{\circ}0/00$; the increase of the salinity in the neighbourhood seems to indicate that these values are trustworthy (and not errors due to evaporation through the cork-stoppers). The actual course along which this water has travelled is difficult to trace; but it appears most probable that the water has followed the edge of the bank (the Continental Shelf) or very nearly the isobath of 300 metres (see Fig. 1, p. 24), and that it is a continuation of the water with salinity above $35^{\circ}0/00$, in about 19° E. Long. along the *Capella's* route to the south, in June. There may be a tendency towards a cyclonic movement as indicated by the isohalines on the chart (Pl. I), colder and less saline water extending southwards from the vicinity of Bear Island. The observations at the stations of the *Michael Sars* in July 1901, also seem to support the correctness of this view.

It is a noteworthy fact that the surface temperatures and salinities found during Dr. Hjort's cruise with the *Michael Sars* in these waters in September 1900, indicate a very similar course of the isohalines and isotherms in this region²; which seems to prove that the above peculiar distribution of the salinity is not due to accidental conditions prevailing

¹ My chart showing the surface temperatures and salinities of the Barents Sea about Aug. 1, 1893, (*Oceanography of N. P. Basin*, Pl. II) was based on much more scanty and less accurate material. It gives a somewhat different representations of the distribution of salinity; but the general features agree to some extent. The values of the salinities are on that chart about $0^{\circ}15/00$ higher than the values now obtained by Knudsen's Tables.

² Nansen, *Nyt Mag. f. Naturvidensk.* vol. 39, Christiania, 1901, Pl. I. See the isotherms for 6° C. and 7° C. The values of the salinity are here about $0^{\circ}12/00$ higher than the values computed by Knudsen's Tables. South of Bear Island the isohaline for $35^{\circ}0/00$ ($= 34^{\circ}9/00$) should probably have had a form more like the isotherm of 8° C.

only in June and July 1901, but is of a more general nature. Very peculiar is the apparent island of water with a salinity of about 34.88 ‰ in the route of the *Capella* in about $71^{\circ} 50'$ N. Lat. and $17^{\circ} 30'$ E. Long.

In September, 1900, a very similar feature was found in the same region, and it seems probable that the tongue of less saline water very frequently extends as far south as this and takes part in the cyclonic movement.

IV. The Cold and Heavy Bottom-Water of the Barents Sea.

Dr. N. Knipowitsch has recently given a most valuable description of the Physical Oceanography of the Barents Sea¹, based upon the excellent Russian investigations during recent years, since 1900, and led by himself and by Dr. Breitfuss. This subject will not be touched in detail here; the reader is referred to Knipowitsch's paper. Amundsen's series of temperatures and salinities from this sea, in April and May 1901, will, however, form a valuable addition to the Russian investigations, as they give information about the conditions in the southeastern part of the sea, earlier in the season than has hitherto been acquired, and they demonstrate clearly the great difference between the conditions obtaining in winter and in summer, which has been already pointed out by Knipowitsch. Amundsen's observations especially, give us valuable information about the formation of the cold water during the winter, which is found as a cold layer near the bottom in summer.

As it is of much importance for our subject, "the origin of bottom-waters", the formation of this cold bottom-water of the Barents Sea and its distribution will be discussed here somewhat more closely.

In his memoir on the "North Ocean" Professor Mohn mentions the low bottom-temperatures of the Barents Sea, and gives a map of the bottom-isotherms². As it is based on the imperfect observations of various previous expeditions this map cannot be expected to be correct, but still it gives a very characteristic feature, *viz.* the rapid sinking of the bottom-temperature towards Novaya Zemlya, where even as low temperatures as -2.6° C. (!) and -2.1° C. had been observed, as was often the case with the imperfect instruments of those days.

¹ N. Knipowitsch, Hydrologische Untersuchungen in Europäischen Eismeer, *Annalen der Hydrographie und Maritimen Meteorologie*, 1905.

² H. Mohn, The North Ocean, its Depths, Temperature and Circulation. *The Norwegian North Atlantic Expedition 1876—1878*, Christiania 1887, Pl. XXV.

In the writer's memoir on the "Oceanography of the North Polar Basin"¹ attention was drawn to the extremely cold and heavy bottom-water in the eastern part of the Barents Sea, especially off the coast of Novaya Zemlya. At our Stations 1 and 4, in July 1893², water with a temperature of -1.14°C . and -1.11°C . and salinity of 35.01‰ and 34.99‰ ³ was observed near the bottom, whilst the salinity was much lower in all overlying strata. At our Stat. 3 there was a bottom layer nearly 100 metres thick with temperature below -1.3°C ., near the bottom it was -1.63°C . and salinity about 34.88‰ ³. At Wollerbæk's Station II (W II, Fig. 1, p. 24) off Novaya Zemlya ($71^{\circ} 48' \text{N}$. Lat., $49^{\circ} 38' \text{E}$. Long.), on May 31, 1900⁴, the bottom-water (in 120 metres, 8 metres above the bottom) had a temperature of -1.80°C ., and a salinity of 35.165‰ ⁵, which gives a density (σ_t) *in situ* of 28.33. This is the heaviest sea-water which to writers knowledge has been observed anywhere in the Ocean. The salinity of the strata overlying this bottom-layer was 34.88‰ with a temperature of -1.65°C . (see Table later p. 40).

In the summer of 1893, Dr. Knipowitsch also observed the low temperatures of this cold bottom-water at various Stations in the eastern Barents Sea⁶, but his methods of determining the specific gravity was not sufficiently accurate to bring out its very high salinity. In recent years, after 1900, both Dr. Knipowitsch and Dr. Breitfuss have made highly interesting observations on the occurrence and distribution of this cold water⁷. Some observations taken near the bottom⁸, may be given as examples in the Table on the next page.

The writer previously held the opinion⁹ that the cold bottom-water of the Barents Sea is divided into two portions — the *northern cold bottom-water* coming from the sea to the north, northeast, and east, and the *southern bottom-water* having two or three sources, *viz.* bottom-currents from the east and north east, and the surface of the sea itself, which is

¹ *The Norw. N. Polar Exp. 1893—1896, Scientific Results*, vol. III, No. 9, pp. 279—283.

² *Op. cit.* p. 244.

³ All salinities are here computed by means of Knudsen's Tables.

⁴ Nansen, *op. cit.* p. 273.

⁵ As to the accuracy of this value see below p. 40.

⁶ Knipowitsch, *Bulletin de l'Académie imper. des Sciences de St. Petersburg*, vol. VII, No. 3, 1877, pp. 269 *et seq.* (Russian).

⁷ Cf. Knipowitsch, *Ann. d. Hydro u. Marit. Meteorologie*, 1905.

⁸ Cf. Conseil Permanent International pour l'Exploration de la Mer, *Bulletin des Resultats Acquis pendant les Courses Periodiques*, Copenhagen, Aug. 1901, May 1903, May and Aug. 1904.

⁹ *Op. cit.*, p. 280.

Bottom-Observations in Barents Sea.

	Station ¹	Date	N. Lat.	E. Long.	Depth in Metres	Temp. °C	Sal. ‰	σ_t
Southern Coast Bank	N 5	July 27, 1893	69° 43'	54° 23'	50	-1°55	34°55	27°83
	N 6	" 28, "	69° 25'	57° 7'	20	-1°67	'22	'55
	W I	May 25, 1900	69° 0'	41° 0'	65	-1°65	'10	'46
	A 6	" 9, 1901	69° 32'	45° 37'	60	-1°88	'39	'71
	A 7	" 12, "	69° 40'	46° 30'	80	-1°24	'77	'99
Novaya Zemlya Coastal Shelf	N 3a	July 25, 1893	71° 22'	50° 6'	127	-1°63	34°88	28°09
	N 4	" " "	71° 23'	51° 36'	70	-1°11	'99	'17
	W II	May 31, 1900	71° 48'	49° 38'	120	-1°80	35°17	'33
	M 57	Aug. 5, 1901	75° 1'	54° 55'	150	-1°8	'04	'23
	R 17	Aug., 1902	74° 2'	52° 36'	150	-1°64	34°87	'09
	R 18	" "	74° 20'	54° 28'	150	-1°7	35°07	'25
	R 19	" "	75° 7'	54° 51'	175	-1°65	34°99	'19
	R 20	" "	75° 35'	56° 16'	150	-1°70	35°05	'23
	R 22	" "	76° 29'	59° 10'	113	-1°02	'03	'20
	R 24	" "	76° 13'	55° 0'	100	-1°70	'03	'22
	R 8	Aug. 6, 1903	71° 12'	49° 45'	120	-1°73	34°83	'06
	R 8	Aug. 3, 1904	71° 13'	51° 0'	135	-1°6	35°01	'20
Central Hollow of Eastern Ba- rents Sea	N 1	July 22, 1893	70° 43'	39° 20'	200	-1°14	35°01	28°19
	R 10	Aug., 1902	72° 42'	47° 52'	270	-1°27	34°92	'12
	R 13	" "	73° 14'	50° 18'	260	-1°46	35°03	'21
	R 29	" "	75° 42'	47° 5'	300	-1°4	34°99	'18
	R 30	" "	75° 34'	45° 28'	300	-1°4	'96	'15
	" "	" "	" "	" "	310	-1°25	35°07	'23
	R 31	" "	75° 31'	44° 2'	300	-1°3	34°90	'11
	R 32	" "	75° 27'	43° 45'	310	-1°38	35°05	'22
	R 7	May 5, 1903	71° 30'	38° 0'	260	-1°85	34°94	'15
	R 26	Aug. 28, 1903	71° 38'	38° 0'	330	-1°84	'94	'15
	R 11	" 7, "	73° 29'	43° 5'	350	-1°8	'97	'18
	R 10	" 7, "	72° 42'	46° 45'	265	-1°79	'92	'13
	R 9	May 15, 1904	71° 30'	37° 52'	320	-1°8	'90	'12
	R 24	Aug. 21, "	71° 30'	37° 55'	285	-1°1	'96	'14
	R 22	" 19, "	73° 8'	41° 40'	300	-1°75	'94	'15
Channel com- municating with Central Hollow	A 11	May 31, 1901	73° 7'	36° 43'	300	-1°40	34°94	28°14

cooled during the winter. The observations of later expeditions, however, enforce a modification of this view. It is now seen that the bottom-water of the Barents Sea has only a very local character, its salinity and temperatures often varying much from one locality to another (*cf.* the above Table and Amundsen's observations at Stats. 1—12); consequently, it cannot be carried, to any great extent², into this sea by currents. Its chief source is obviously the latter of those mentioned above, *viz.* the surface of the Barents Sea itself, which is much cooled by radiation of

¹ N = Norwegian North Polar Expedition 1893—1896; W = Wollebæk on board the Heimdal, 1900; A = Amundsen's Stations in 1901; R = Russian Stations.

² That such regular extensive bottom currents should be able to traverse the many unevennesses and ridges on the bottom in such a shallow sea seems also *a priori* extremely improbable.

heat during the winter. The vertical circulation thus produced reaches the bottom in all parts of the sea, where the horizontal circulation is not too rapid, especially in the shallower waters over the banks (as is beautifully demonstrated by Amundsen's Stat. 6), but also, as will be mentioned below, in the northern central part of the central hollow or basin of the eastern Barénts Sea. As pointed out in the above mentioned memoir¹ it is "highly probable that the sea-surface in the neighbourhood of the coasts, has a considerably higher salinity at the end of the winter than during the summer, for the water is then less diluted by the admixture of fresh-water from the rivers and the land, and its salinity is on the other hand increased by the formation of ice on the surface"². It is thus easy to understand how it is, that, in the summer, the cold bottom-waters which are remnants of the cold winter-water, have higher salinities than the overlying water-strata. The top-layers of the sea are then also much diluted by the melting of the ice-masses formed during the winter. As the salinity varies much in the different regions of the shallow sea, it may also be expected that the salinity of the bottom-water in these same regions will vary accordingly. Over the deeper hollows and channels of the sea there is more atlantic water with higher salinity, but there is also at the same time more horizontal circulation in the various water-strata, and the vertical circulation has greater difficulties in reaching to the bottom. The very cold bottom-water is, therefore, more easily formed on the shallower banks and on the shelves near the coasts.

The many series of observations now taken, by Knipowitsch, Breitfuss, Wollebæk, Makaroff, and Amundsen, give a fairly clear idea of the formation of the cold bottom-water of the Barents Sea, and of its distribution in the months between spring and autumn. Distinction may perhaps, for the sake of clearness, be drawn between four cold bottom-waters, formed in four different regions, *viz.*

1) Cold bottom-water with a comparatively low salinity formed on the southern bank or shelf, with very shallow water, north of the Russian coast, where the sea-water is much diluted by water from the great rivers (typical example is Amundsen's Stat. 6, see Pl. IV, Sect. III).

2) Cold bottom-water, often with a remarkably high salinity near the bottom, formed on the shelf along the west and southwest coast

¹ *Op. cit.* p. 280.

² The same explanation of the origin of the cold bottom-water is also partly accepted by Dr. Knipowitsch in his recent paper, *loc. cit.*, 1905.

of Novaya Zemlya (typical example is Wollebæk's Station II, May 31, 1900).

3) Cold bottom-water, probably with moderately high salinities,

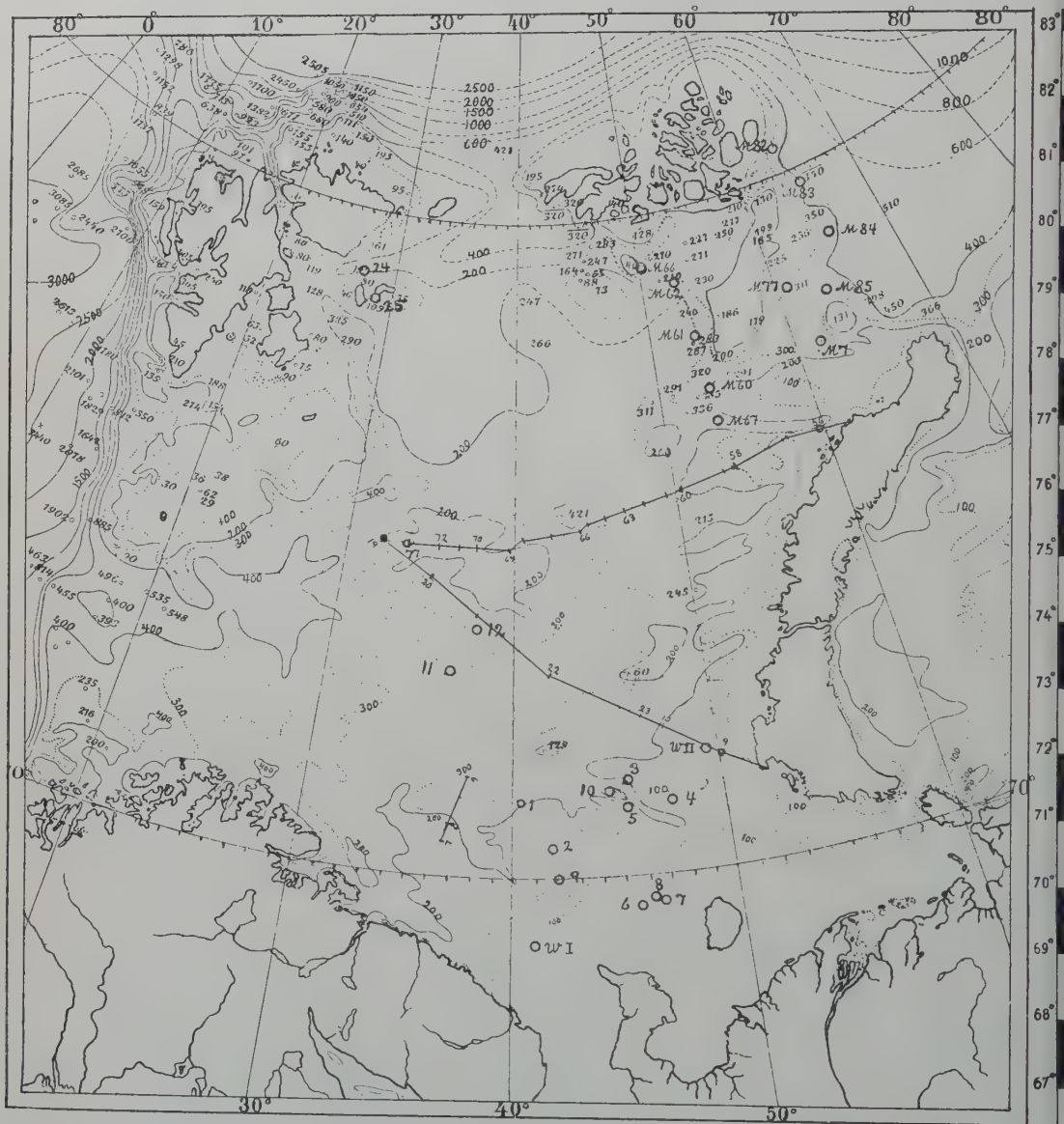


Fig. 1. Bathymetrical Map of the Barents Sea. Scale 1 : 12,000,000.

Isobaths for every 200 metres, and dotted lines for the isobaths of 100 and 300 metres.

formed over the shallow banks in northern Barents Sea (there are no accurate observations of this water).

4) Cold bottom-water, with about the same salinity as the Atlantic water in the western Barents Sea (about or above 34.9 ‰), filling the

central part of the great central depression of the eastern Barents Sea (see Figs. 2 and 3, pp. 26, 27, and Pl. III) frequently with a thin layer of higher salinity close to the bottom.

Horizontal Circulation. It is a striking fact that in most sections, at least in the spring and summer (*e. g.* Pl. IV, Sections I and II, and Figs. 2, 3, on pp. 26 and 27) there seems to be no connection between the latter bottom-water and that of the banks to the west and south; for on the slope of the central depression there is, even in April and May (Pl. IV, Sects. I and II), water with temperature above zero; and it seems as if no cold bottom-water is formed on this slope¹. The reason is probably that along the slope there is too much horizontal movement of the water, which renews the water-masses too rapidly to allow the vertical circulation during winter, to cool the whole bulk of water down below zero.

On several previous occasions² it has been pointed out that the oceanographical conditions of the Barents Sea beautifully illustrate how the currents have a tendency to follow the deepest channels of the sea bottom³. Where the moving water meets a projection on the sea-bottom, it is deflected towards the sides, and if there be openings the water will follow the lines of least resistance. It will, more or less, run outside these projections or banks along their side slopes, even though

¹ Dr. Breitfuss's Section IV, from Kola-Fjord to Mototchkin Shar, Aug. 4—9, 1902 (*Petermann's Mitteilungen*, 1904, Pl. 4) seems to form a remarkable exception, as it shows no warmer water in the eastern part of the Sea, near the land slope, but there have evidently been quite exceptional conditions at that period, and besides the eastern part of this section must have been in a deep submarine fjord (*cf.* Fig. 1, p. 24) approaching the Novaya Zemlya coast so near that there is hardly indication of a coast bank or shelf in the section. If the many other soundings known from this region be correct, there must be very shallow sea both north and south of this fjord, and if so there may be comparatively slow circulation in it. Sections across the same region as Breitfuss's Stations 43 and 44, in other years — *e. g.* Breitfuss's Section Fig. 3, p. 27, from Aug. 1904; his Section across the same region in Aug. 1903 (*Bull. Courses Period.*, Pl. V, Arct. II); and Knipowitsch's Section a little farther north, from July 13—19, 1901 (*Ann. Hydr. u. Marit. Meteor.* 1905, Pl. 6, Fig. 5) — show the typical separation, by warmer water on the slope, between the cold bottom water of the coast bank and that of the central hollow. It seems probable that in Aug. 1902, there has been a similar temporary displacement of the waters as was observed at Amundsen's Stats. 9 and 10, in May 1901 (see below), and also on the slope on the southern side of the Central Hollow in May, 1903 (see below).

² Nansen, *op. cit.* pp. 260 *et seq.* See also, Some Oceanographical Results of the Expedition with the Michael Sars in the Summer of 1900; *Nyt Mag. for Naturvidenskaberne*, vol. 39 Christiania, 1901, p. 152.

³ Dr. N. Knipowitsch has in several papers (*cf. op. cit.*), carried through the same principle and has shown in detail, how the Atlantic current of the Barents Sea divides into several branches regulated by the depressions of the bottom.

they may not rise very high above the deeper channels. The water over these banks will consequently remain comparatively stationary, forming, as it were, islands of quieter and often heavier (*cf.* the Novaya Zemlya coast shelf) water, where the horizontal circulation is much reduced, and the vertical circulation may therefore be so much the more effective¹. As the horizontally moving water is much deflected towards the right by the Earth's rotation, in these high latitudes, it will have a strong tendency to move along the side-slopes of the great hollows and not along their central axes. Where a hollow is great, a cyclonic movement

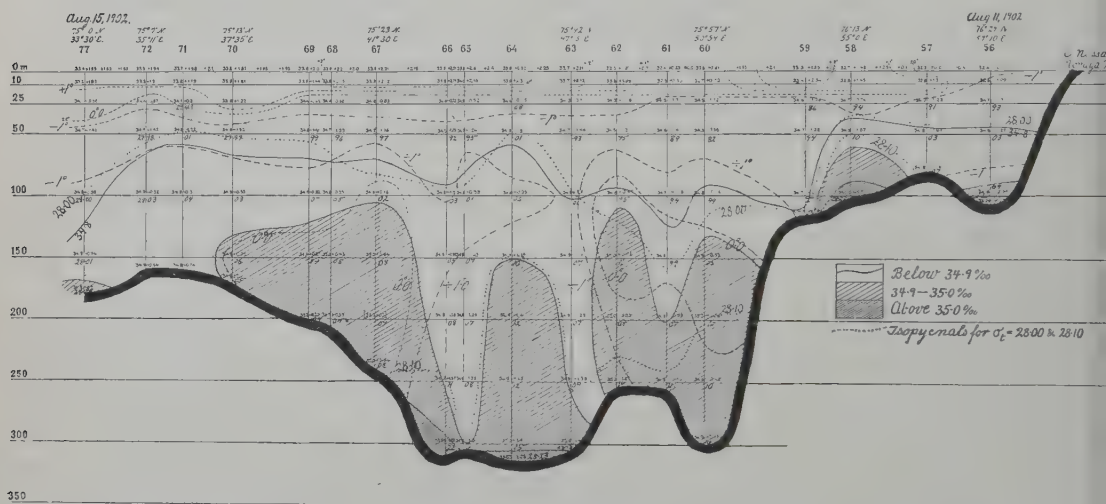


Fig. 2. Section, Aug. 1902, from Breitfuss's Station 56 to his Stat. 77, see line Fig. 1. Horizontal Scale 1 : 6,000,000. Vertical Scale about 1000 times exaggerated.

may be produced in this way and the water in the central portion of the hollow may have a comparatively slow horizontal movement, whilst the water along the slopes, especially on the southern and eastern side of the hollow, will move comparatively rapidly. Such seems, for instance, to be the case in the great central hollow, more than 300 metres deep, of the eastern Barents Sea, between 40° and 46° E. Long. (see Fig. 1, p. 24), as will be mentioned below.

The surface map of the Barents Sea (Pl. I), and the maps, Pls. II. and III, showing the horizontal distribution of salinity and temperature, in the summer, at 50, 100, 200 and 300 metres, illustrate roughly the main features in this horizontal circulation. The latter maps are based chiefly

¹ This may also be the reason why fishes in different regions of the Ocean seek such banks for spawning. There being comparatively little horizontal circulation, there is less risk of the eggs being carried away by currents. This is clearly demonstrated by Dr. J. Hjort's investigations on the distribution of fish-eggs in the spring on the Norwegian coast banks.

on Dr. Knipowitsch's sections from July and August, 1901, and on Dr. Breitfuss's observations from August 1904, and 1903, and to some extent also 1902. The construction of the north eastern part of the map, the sea between Novaya Zemlya and Franz Josef Land, is based on Admiral Makarof's observations from August, 1901.

Vertical circulation. The cooling of the sea-surface by heat radiation is very considerable during the winter, in the Barents Sea, and a

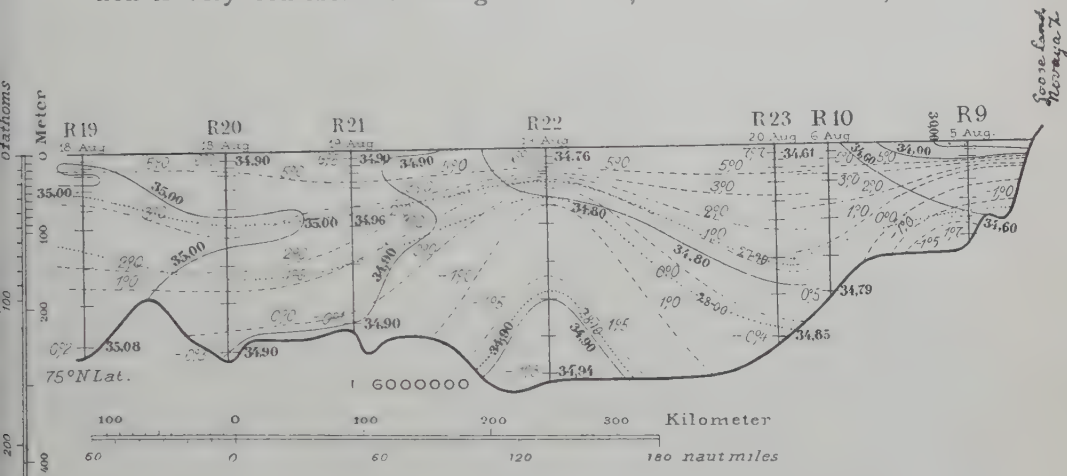


Fig. 3. Section, Aug. 1904, from Russian Stat. 9 ($71^{\circ} 43' \text{ N.}, 50^{\circ} 25' \text{ E.}$) to Stat. 19 ($75^{\circ} 0' \text{ N.}, 32^{\circ} 18' \text{ E.}$), see line Fig. 1. Horizontal Scale 1:6,000,000. Vertical Scale 300 times exaggerated. The dotted lines are isopycnals for $\sigma_t = 27.90, 28.00, \text{ and } 28.10$.

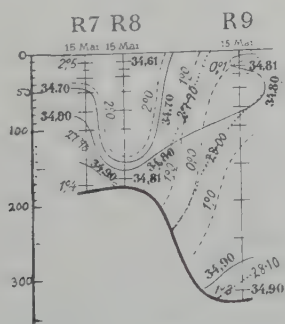


Fig. 4. Section, May 1904, from Russian Stat. 7 ($70^{\circ} 30' \text{ N.}, 36^{\circ} 40' \text{ E.}$) to Russ. Stat. 9 ($71^{\circ} 30' \text{ N.}, 37^{\circ} 52' \text{ E.}$), see line Fig. 1. Horizontal and vertical Scale same as in Fig. 3.

very deep vertical circulation is thus produced¹. Vertical series of temperatures and salinities taken in the spring, show as a rule distinct traces of this vertical circulation in most parts of the Barents Sea, but especially over the banks. Amundsen's southern Stations, especially

¹ Dr. Knipowitsch has specially discussed the seasonal changes in temperature and salinity. Cf. *op. cit.* pp. 299 *et seq.*

Stat. 6 (see Table II); are good illustrations. Wollebæk's Stations (see below pp. 35, 40), of May 25 and 31, 1900, are equally good. In the case of the Russian observations taken early in the season, similar traces are found. As an example Station 6, on May 4, 1903, in $73^{\circ} 40' \text{ N. Lat.}, 33^{\circ} 29' \text{ E. Long.}$ (depth 315 metres) may be taken¹. The salinity was nearly uniform, $35.03-35.05 \text{ ‰}$, between 15 metres and 310 metres, near the bottom. The temperature was about 1.9° C. and 1.99° C. between 5 metres and 150 metres; deeper it was about 1.4° C. ². The vertical circulation, communicating directly with the surface, has reached, at least, down below 150 metres. This was near the middle of the deep channel, west of Amundsen's Stat. 12 (see Fig. 1), running eastwards into the deep hollow of the eastern Barents Sea. Stat. 5 (May 4, 1903) was on the slope on the south side of this channel, in $73^{\circ} 32' \text{ N. Lat. and } 32^{\circ} 25' \text{ E. Long.}$ (depth 294 metres), and here there has evidently been more horizontal movement, for the vertical circulation has not managed to make the water homogeneous down below 50 metres (about 2.1° C. and 35.05 ‰). Stat. 7 (May 5, 1903) is in the southern part of the great central hollow, on its western slope in $71^{\circ} 30' \text{ N. Lat. and } 38^{\circ} 0' \text{ E. Long.}$, and here there has also been rather much horizontal circulation, as the vertical circulation has only been able to make the water homogeneous (about -1.45° C. and 34.70 ‰) down to 40 metres (as to the rapid horizontal movement on this slope see below).

At Stations 8 ($70^{\circ} 45' \text{ N. Lat.}, 36^{\circ} 56' \text{ E. Long.}$, depth 166 metres) and 9 ($70^{\circ} 32' \text{ N. Lat.}, 36^{\circ} 38' \text{ E. Long.}$, depth 188 metres) which were taken at the same time on the flat bank south of this hollow, the vertical circulation has made the water practically homogeneous between the surface and bottom, with a higher temperature and salinity (about 1.08° C. and 34.96 ‰) at the northern Station, which is nearer the deeper hollow. Here the vertical uniformity has not been so complete as at the southern Station (about 0.59° C. 34.88 ‰), where there has been less horizontal circulation. The salinity was there probably perfectly uniform (34.87 or 34.88 ‰), whilst the temperature was somewhat lower (about 0.58° C.) in the upper water-strata than in the lower (about 0.65 and 0.69° C.), which might seem to indicate, if the observations be

¹ *Bull. d. Results acq. p. l. Courses Period.*, May, 1903, p. 212.

² Between 0 and 10 metres there was between 34.88 and 35.01 ‰ and 1.85° C. This lowering of temperature and salinity near the surface has evidently been caused by the melting of some ice, which was met with at this Station. The ice cannot have been very long in this water, for else the surface layers would have got a much lower salinity.

perfectly accurate, that the cooling on the surface was still going on, on May 6, 1903.

In May, 1904, the conditions were different in this same region; the temperatures were higher and the salinities lower.

It is on this same flat coast bank or shelf that Wollebæk's Stat. I, (May 25, 1900, see Fig. 1, *W I*) and Amundsen's Stat. 6, (May 9, 1901), are situated. They show an equally complete vertical circulation, but with much colder water (-1.65° C. and -1.8° C.) and lower salinities (34.06 ‰ and 34.40 ‰), which might be expected, as they are nearer land.

In these same regions later in the season, there will be found entirely different conditions. The upper strata are then much warmer, and on the banks the salinity is, as a rule, much lower. As example a comparison between the observations in the vertical series below, may serve.

Depth in Metres	Stat. 10 May 28, 1904 69° 45' N. 37° 20' E. Depth 116 m.	Stat. 1 Aug. 1, 1904 69° 44' N. 37° 20' E. Depth 116 m.	Stat. 13 May 29, 1904 70° 42' N. 46° 0' E. Depth 110 m.	Stat. 4 Aug. 2, 1904 70° 41' N. 46° 0' E. Depth 110 m.	Stat. 14 May 29, 1904 70° 47' N. 47° 8' E. Depth 159 m.	Stat. 5 Aug. 3 1904 70° 48' N. 47° 0' E. Depth 155 m.	Mean Differen- ces be- tween May and August 1904
0 {	2.0 34.31	8.79 34.29	1.39 34.74	7.8 34.45	1.1 34.87	7.8 34.31	6.6° C. 0.29 ‰
20 {	1.68 34.60	8.2 34.45		6.42 34.54		6.02 34.70	6.2° C. 0.17 ‰
30 {	1.55 34.60	3.7 34.63	1.1 34.76	2.72 34.63	1.2 34.87		2.4° C. 0.09 ‰
50 {	1.5 34.56	1.65 34.60	0.83 34.74	1.5 34.67	1.1 34.72	2.62 34.72	0.8° C. 0.06 ‰
75 {	1.35 34.61	1.65 34.63	0.55 34.79	1.1 34.67	1.05 34.81	1.9 34.81	0.6° C. 0.06 ‰
100 {			0.5 34.81	0.25 34.67	0.85 34.87	1.23 34.79	0.35° C. 0.07 ‰
110 {	1.35 34.61	1.65 34.63					0.3° C.
150 {					0.05 34.88	0.5 34.76	0.55° C. 0.12 ‰

It is seen, that the difference in temperature, produced in 65 days, is very nearly the same at the three different places above, being slightly higher at the western Station. It is between 6.4 and 6.8° C. near the surface, between 5.9 and 6.5° C. in 20 metres, between 0.15 and 1.5° C. in 50 metres, between 0.3 and 0.85° in 75 metres, about 0.3 or 0.4° C. in 100 metres; and 0.55° C. in 150 metres. But the differences in salinity are on the whole considerably greater at the eastern Stations.

In the deeper western parts of the sea, which is more exposed to horizontal circulation, and farther away from land and from the region

in which great ice-masses melt, there is much less difference between the salinities in spring and autumn; and also less difference in temperature near the surface. As example, observations from a few depths of the Station 5, of May 4, 1903, mentioned above, may be taken and compared with those at the same place taken in August, 1903.

Depth in Metres	Stat. 5 May 4, 1903 73° 32' N. 33° 25' E. Depth 294 m.		Stat. 16 Aug. 9, 1903 73° 30' N. 33° 20' E. Depth 290 m.		Difference	
	° C.	‰	° C.	‰	° C.	‰
0	2'1	35'01	5'7	35'01	3'6	0'00
40	2'07	35'05	5'7	35'03	3'63	0'02
50	2'03	35'07	4'59	35'05	2'56	0'02
100	1'91	35'05	3'62	35'07	1'51	— 0'02
200	1'63	35'07	2'89	35'10	1'26	— 0'03
250	1'49	35'07	1'86	35'05	0'37	0'02
280	1'44	35'07	0'95	35'03	— 0'49	0'04

This is exactly what might be expected; there is practically no difference in salinity. At some depths (100 and 200 metres) it is rather in the opposite direction. The difference in temperature is much less near the surface than at the former Stations; but the heat wave has been able to go much deeper, owing to the uniformity of salinity which has much facilitated the intermixture of the upper water-strata. The difference in temperature is therefore the same at 40 metres as near the surface; at 50 metres it is 2'56° C. whilst it was only 0'8° C. at the former Stations. In the deeper strata the difference is also considerably higher. Near the bottom some different water has evidently come in, and made the temperature lower.

Formation of the Cold, Heavy Bottom-water.

From what is said above, it may be concluded that bottom-water is formed in many parts of the Barents Sea by surface cooling during the winter; but the temperature as well as the salinity of the bottom-water will greatly depend on the local conditions, and may even vary on the same bank, if somewhat extensive. The necessary conditions for the formation of very cold bottom-water are, that the waters at all depths are fairly stationary, and free from any rapid horizontal circulation, so that the vertical circulation caused by cooling at the surface during winter, may gradually reach the bottom, and give to all water-strata a nearly uniform salinity, temperature, and density. After this has been attained, continued cooling will reduce the temperature of the whole

bulk of water, and the formation of ice on the surface will gradually increase the salinity, especially wherever the sea be shallow. This increase of salinity by ice-formation must obviously be the explanation of the remarkable fact, that the heaviest bottom-water, *e. g.* on the coast banks of Novaya Zemlya, has very often a higher salinity than was ever found in the comparatively warm Atlantic water of the eastern Barents Sea. If for instance, it be supposed that by the vertical circulation of the water during the winter, the salinity has become almost uniform, about 34.70 ‰ (*cf.* Russian Stat. 10, Aug. 6, 1904, in Table below) from the surface to the bottom, in a region where the sea during the winter and spring be covered by a layer of new ice, with a mean thickness of 2 metres¹, the salinity of the underlying 198 metres of water will be increased by about 0.33 ‰ , and instead of 34.70 ‰ the mean salinity will become about 35.03 ‰ . If the sea be shallower, the formation of 2 metres of ice during the winter would increase the salinity by still more. If the sea be only 100 metres deep it would in this way be possible to start with a water of mean salinity 34.4 ‰ , and still get water with a salinity above 35 ‰ after 2 metres of ice had been formed. The effect of ice-formation may naturally be somewhat reduced locally by horizontal circulation in the sea, carrying a new supply of water in under the ice; but still the effect upon the whole mass of the water will be the same, and wherever ice is formed, it may consequently be expected that the salinity will be higher in the winter than in the summer, as is also actually borne out by the observations.

The cold, heavy water thus formed, will sink and spread out on the banks, and if it be heavier (either on account of lower temperature or higher salinity) than the bottom water on the same level or at lower levels in the neighbourhood, it will gradually creep along the bottom in under such waters. This is probably the explanation of the very frequent and sudden occurrence at a great many stations, of a thin bottom-layer of higher salinity and density, and a temperature generally lower, but sometimes higher, than the overlying water.

¹ The formation of ice on the surface during winter, is much helped by ice-pressures, which breaks the ice, and piles the floes up into high hummocks. When the pressures ceases again, open lanes and channels are formed which are rapidly covered by new ice, again to be broken and piled up. Thus ice-pressure greatly increases the formation of ice as well as the cooling of the sea. If the ice were not continually being broken, but formed a continuous and permanent sheet, it would increase extremely slowly after having attained a certain thickness, and after being covered with much snow, and the underlying water would be protected against cooling.

As this heaviest water close to the bottom, has sometimes salinities higher than were ever observed in the vicinity in higher strata, it might seem somewhat difficult to believe that the salinity at some place in the same region, could have been, during the winter, so high in all strata between the surface and the bottom, at least for any length of time. If it be supposed however, that the vertical circulation during winter, had established a nearly uniform density between surface and bottom; further that the temperature had been lowered towards freezing-point, and that the salinity had been increased by formation of ice; and if then, on extremely cold days, great open lanes had been suddenly formed in the thick ice, and thus a great open water-surface suddenly exposed to very rapid cooling, there would have been a very intense formation of ice. The upper water-stratum might in this way be cooled down and its salinity increased more rapidly than it could be replaced by vertical circulation. The very heavy water thus formed might then sink through the underlying water and might perhaps in some cases, especially where the sea is shallow, reach the bottom before it was too much intermixed with intermediate strata. If such a lane be covered with new ice, and reopened several times, as is very frequently the case¹, the effect of the local cooling and rapid formation of ice might be still more increased, and a column of very cold and saline water might actually be formed for a while between the surface and the bottom. But as soon as the sea-surface is again covered by thicker ice, the very heavy water, will sink below the upper strata, and regular, more uniform conditions will be reestablished, while the heavy layer will remain on the bottom².

¹ The ice-pressure is generally repeated very regularly with the tidal currents, along such channels and lanes in the ice, where a line of weakness has been formed. In the intervals between the pressures the channels are widely opened. This happens especially at the time of spring-tide.

² Professor Edlund's theory (cf. *Övers. Kongl. Vet. Akad. Handlingar*, Stockholm, 1863) that, under certain conditions, ice might be formed near the bottom of the sea, if correct, offers another possible explanation of the above fact. Edlund's idea was that the sea-water might be cooled below freezing-point, even though in slight motion, and such super-cooled water might therefore sink towards the bottom without freezing, until suddenly, by some accident, the freezing process be started, and quantities of ice formed which would suddenly rise to the surface. Edlund based his theory upon observations made by E. A. Nordenskiöld, who with a maximum and minimum thermometer actually found temperatures below freezing-point in the sea near Gotland; but with the imperfect instruments of those days too low temperatures were frequently observed in the sea. During Nordenskiöld's Vega-Expedition temperature-readings as low as -2.3° and -2.4° C. were repeatedly taken from the deep water of the Kara Sea, in August 1878, when there was no possibility of super-cooling. And at Vega's winter-harbour near Bering Straits, temperature-readings as low as -2.8° and even -3.0° C. were taken in water from 2, 4 and 6 metres below the ice-covered surface (cf. O.

In the days from April 29 to 30, from May 3 to 9, and from May 23 to 28, 1901, Amundsen sailed through water which was cooled down to its freezing point (-1.9°C). The water-samples, taken with the glass water-bottle of his own construction, from 5 and 10 metres below the surface, give frequently during those days remarkably high salinities, sometimes even above 36 ‰. The reason is obviously that ice has, frozen out on the walls of the glass collecting bottle before the samples had been bottled for storage (see above pp. 7–8). On some occasions however, the salinities have been lowered by small ice-needles floating in the water, getting into the water-sample. The observations taken in these days are therefore not trustworthy. On the whole, however, the

Pettersson, *Vega Exp. Vetensk. Iakttagelser*, vol. II, pp. 373–374). Observations like these are obviously erroneous; for it is at any rate certain, that sea-water cannot be thus super-cooled, where ice is present on the surface. In spite of hundreds of observations made during the polar winter, the present writer has on no occasion observed temperatures below the freezing-point of sea-water, where ice occurred on the sea-surface. Attention may, however, be drawn to some observations of Amundsen. When he sailed across an extensive open lane in the ice on May 4–5, 1901, he remarks in the journal (see Table I) that he would not record the temperature-readings as they were absurd, the thermometer indicating below -2°C . or even -2.4°C . and he therefore thought that there was something wrong with the thermometer (No. 638) which, however, always gave quite correct readings, even only a few hours before and after these observations (see Table I). It seems difficult to understand what might have been the matter with this evidently very trustworthy instrument, and the possibility does not seem to be excluded that there has actually been super-cooled water in this open lane far from any ice, although it seems hard to understand how such very cold water could be stirred and taken on board in a bucket, without being instantly transformed into ice, but the salinities of the water-samples taken, do not indicate that this has been the case. It is also a remarkable fact that on May 4 and April 29, Amundsen repeatedly got readings of -2.0°C .; and his readings have without doubt usually a high accuracy.

Edlund also mentions that Nordenskiöld on some occasions has observed ice on the bottom of the sea. The present writer has frequently seen the same thing near shore. The explanation was, however, that at these places the ice had been frozen solid to the bottom during the winter, afterwards during the summer it had been partly broken away by pressure and partly melted near the surface, while it still remained between the stones on the bottom.

It has to be remembered that when the water is exposed to higher pressure by sinking, its temperature is slightly raised, while its freezing point is lowered, and it does not, therefore, seem very probable that under regular circumstances ice may be formed below the surface in this manner.

In another way, however, ice may be formed at some distance below the sea-surface. During pressure the ice-floes are broken and piled up in hummocks, which may often reach down to depths of 40, 50, or perhaps even 60 metres or more. The ice thus pressed down during the coldest part of the winter, may have temperatures of between -20.0° and -30.0°C . (*cf. The Norwegian North Polar Exp. 1893–1896, Scientific Results*, vol. VI, No. 17, pp. 544–557), and before this ice is heated by the water to its freezing point, much new ice may naturally be formed, as the writer has also verified by direct observations; the salinity of the water is of course increased as a result.

surface salinity was remarkably high (about 34.7 and 34.8 ‰), in these regions where the sea-water was cooled towards its freezing-point, and where much new ice was being formed while Amundsen was there. The surface-salinity is during the summer and autumn very low in these same regions (see the isohalines Pl. I), and sinks even below 34 ‰. It shows clearly how ice-formation is able appreciably to increase surface-salinity.

When the cooling of the surface ceases in the spring, the coldest and heaviest water will gradually sink towards the bottom, and lighter and warmer water which is heated from above, will replace it near the surface. The salinity of the top-layers will be reduced by the melting of the ice, and also by an increased quantity of fresh-water from the rivers and from the land. The salinity of the water near the bottom will be gradually lowered by intermixture with the overlying water; and it may therefore be expected that higher salinities, for the cold bottom-water on the shallow banks, will be found early in the spring and lower ones later on (cf. Wollebæk's Station on May 31, 1900). During the course of the late summer and autumn, the cold bottom-water may gradually be washed almost entirely away on the shallow banks, by intermixture with the overlying warmer layers; but it will remain for a long time as a thin layer in the deepest hollows, and will there never entirely disappear; especially along the Novaya Zemlya coast¹. In the deep central hollow of the eastern Barents Sea it will probably always form a bottom-layer of greater thickness (see above Figs. 2, 3).

The cold winter water of the southern shallow part of the Barents Sea.

Amundsen's Stations 1 to 10 are taken on the southern extensive coast bank or plateau, with depths less than 100 metres (see Fig. 1, p. 24), and on its northern slope. They are from an earlier part of the season (April and May) than are most other observations known from this region, and the vertical series shows very distinct traces of the vertical circulation during the previous winter and spring, which has produced almost homogeneous cold water between surface and bottom at the most typical Station, Stat. 6. Here the density (σ_t) of the water

¹ In the writer's memoir on the N. Pol. Basin, where a similar explanation is given (cf. *op. cit.* p. 281) it is suggested that similar bottom-water may also find its way into the Kara Sea from the North, and thence through the Kara Strait into the submarine channel along the southwestern coast of Novaya Zemlya. This seems now, to be very doubtful. On the whole it seems that this cold bottom-water is much more local and forms much less of cold bottom-currents than then seemed rather likely, and also less than Knipowitsch seems to think.

was 27.70 and the salinity 34.39 ‰. As the sea-water over this extensive, submerged coastal platform is much diluted by water from the great rivers (of the White Sea, the Pechora, etc.), and as the shallowness of the sea prevents an active horizontal circulation bringing in fresh supplies of Atlantic water from the north, it must be expected that comparatively low salinities with considerable local variations will be found. This is in accordance with Amundsen's actual observations. It is seen that both his numerous surface observations (cf. Pl. I) and his vertical series of observations show striking differences in temperature and salinity, often in regions which are not far apart; their horizontal and vertical distribution is also greatly influenced by the local conditions. For example take the three most southern Stations, Stats. 6, 7, and 8 (see Table II), covering a period of 7 days (May 9—16, 1901), and very near each other on the extensive flat bank west of Kolguyev. At the most western Station, Stat. 6, with the shallowest water, the vertical circulation has been most complete, the temperature of the bottom-layers being near freezing-point, and the salinity comparatively low. At the most eastern Station, Stat. 7, there was higher temperatures and higher salinity near the bottom, showing the influence of the deeper channel or depression coming from the north and producing more horizontal circulation in the deep waters. But near the surface the temperature is higher and salinity lower showing the influence of the nearer vicinity to land. Stat. 8 shows an intermediate position between the two, both locally and with respect to temperature and salinity, but having been taken several days later, it has got higher temperatures near the surface.

A Station taken by Mr. Alf Wollebæk further west on the same platform, on May 25, 1900, is also very interesting.

Wollebæk I.	69° 0' N. Lat.	Depth in Metres	0	10	20	40	65
May 25	41° 0' E. Long.	Temp. ° C. . .	—1.65	—1.65	—1.65	—1.65	—1.65
1900		Salin. ‰ . .	34.06	34.06		34.06	34.10

This station is just north of the outlet from the White Sea, and consequently a still lower salinity than at Amundsen's Stat. 6 may be expected. It is a very common feature that near the bottom, the salinity is higher than in overlying perfectly uniform strata¹.

¹ The salinities are here computed according to Knudsen's Tables. They were determined by Dr. Heidenreich by Titration, and by the aid of a standard water, the salinity of which had not been accurately determined, when the memoir on the Oceanography of the North Polar Basin (cf. *loc. cit.* p. 261) was written. Heidenreich's original

The sections (Pl. IV, Sections I—III) constructed for some of Amundsen's Stations in this region, are rather instructive. Sect. III shows how cold water, with uniform low temperature and salinity, occurs on the coast bank (Stat. 6), whilst near to, or on the northern slope (Stats. 5 and 3) of the bank, there were, more than a week earlier, much higher temperatures and salinities, with a warm intermediate layer in which the salinity approaches that of the Atlantic water of the Barents Sea. This shows the effect of the more rapid horizontal movement of the water along the slope. Section II, shows the difference between Stat. 5, which is in a channel¹ near the slope, communicating with the warm current along the latter, and the two Stations 2 and 4 on the banks on both sides. But at none of these Stations has there been such perfect vertical circulation, as at Stat. 6. Stat. 4 has been too near the channel at Stat. 5, and has an intermediate warmer layer (maximum of -0.21° C.) and a comparatively high salinity (about 34.83 ‰), and Stat. 2 was near the slope of the submarine valley, coming from the north, west of Long. 40° E. (see Fig. 1, p. 24).

Section I is interesting as it demonstrates a remarkable change in the water-masses, which has obviously occurred between April 26, when Stat. 2 was taken, and May 20 and 22 (Stats. 9 and 10). Where Amundsen's route, between May 22 and 23, crosses his route between April 26 and 28 (see Pl. I), it is seen that the surface-temperatures and salinities have become noticeably lower (about -1.5° C. and 34.51 ‰) in May than they were in this region in the end of April (about 0.4° C. and 34.87 ‰). It is obvious that in April there was much water from the Atlantic current, which runs eastwards along the slope of the deep depression (see the isobaths for 200 and 300 metres in Fig. 1, p. 24, and the temperatures and salinities along Amundsen's route between April 24 and 25, Pl. I); whilst in May there had been a displacement of the whole mass of water towards the west, very cold water with lower salinity (between 34.56 and 34.68 ‰) having come from the east (or south?) and filled the sea between surface and bottom, as is seen at Stats. 9 and 10. The whole bulk of warmer

determinations are not now available and it is impossible to compute values accurately, but judging from his values given for Wollebæks Stat. II (see below) the values then published (*op. cit.*) should be reduced by 0.11 ‰.

¹ The exact form and direction of this channel is somewhat difficult to trace, as the soundings of the different expeditions are somewhat contradictory, which may be due to inaccuracies in the latitudes or longitudes. That the channel actually communicates with the great deep depression to the northwest is proved by the warm bottom-water at Stat. 5, and also by several Russian observations in this locality in later years.

Atlantic water had then probably been displaced towards the west. There was, however, found no sign of this water on the surface towards the northwest along the route between May 25 and 27 (see Pl. I and Table I); but there is of course a possibility that there may have been warmer water under the cold surface layer. By studying the chart Pl. I, it is seen that along Amundsen's route between May 20 (Stat. 9) and May 22 (Stat. 10) there was the same kind of surface-water as was formerly (about May 6) found further east¹. The water at the two Stations 9 and 10 is also very much the same at all depths, but entirely different from that of Stat. 2. It is seen that whilst the densities are fairly similar in the deeper strata (*cf.* the isopycnals of 27'90 and 28'00), the densities of the strata near the surface have become much lower (below 27'80), in spite of the low temperatures in May (Stats. 9 and 10), than they were at the end of April (Stat. 2), when they were nearly 27'90. It is easy to understand that such lighter surface layers may move west and northwestwards away from the coasts.

The surface observations in this shallow sea, at this early season, tell much about the underlying strata. It may as a rule be assumed that the temperature and salinity have vertically been fairly uniform. In the most southern region (Pl. I and Table I), visited by Amundsen, the surface salinities approached 34'0 ‰ with temperatures about $-1\cdot2$ and $-1\cdot5^{\circ}$ C., whilst along the most eastern part of his route, the salinities were comparatively high (34'50–34'79 ‰) and the temperatures about the freezing-point of sea-water ($-1\cdot9^{\circ}$ C.). During this time (April 29–30, and May 3–7) the temperature of the air was low (about -7° and -9° C.) and much ice was formed on the sea-surface, which evidently much increased the salinity².

Later in the season the conditions are, however, entirely changed in this part of the sea. The water is heated to considerably higher temperatures, especially near the surface, and being diluted with much river-water and by the melting of ice, its salinities are much decreased (see above pp. 14–15).

¹ It may be possible that an increase of the waters of the river Pechora, flowing into the sea to the south-east, may displace the whole bulk of water some distance towards the north-west, or west; but it seems more probable that winds might be able to produce such a displacement; there had not, however, been much easterly or south-easterly winds during May.

² It has been pointed out above, that water-samples taken during periods with such low temperatures, when the sea-water is cooled to freezing-point, give not very reliable salinities, especially those taken with Amundsen's small water-bottle (see above pp. 7 and 33).

Knipowitsch has a section from August 13—19, 1901¹, which passes south of Amundsen's Stations 6, 7 and 8, but the difference between these and Stations 580 and 581, of the former, is very striking. All traces of the cold water are washed away in August; there was at no depth any temperature below zero, and in the upper strata, above 25 metres, the temperature was above 4°, and even 6° C., whilst the salinities had sunk below 34 ‰, and near the surface even below 33 ‰. Knipowitsch's Stat. 579 (68° 52' W. Lat., 44° 28' E. Long.) is near Amundsen's place on May 11, where he observed -1.2° C. and 34.28 ‰ and -1.4°, 34.05 ‰ on the surface, and there were probably very nearly the same temperature and salinity in all strata to the bottom, whilst Knipowitsch in August the same year found, the temperature above 6° C. and salinity below 32.0 ‰ in the upper 20 metres, whilst, towards the bottom in about 60 metres, the temperature gradually decreased without reaching zero and the salinity increased without reaching 34.0 ‰. All traces of the cold winter-water had consequently been effaced by August.

Knipowitsch's Station 537² has obviously been very nearly at the same spot as Amundsen's Stat. 3, although according to the Latitudes and Longitudes as published it should have been nearer his Stat. 10.

Knipowitsch's Stat. 536 has about the Latitudes and Longitudes of Stat. 3, but was obviously on the platform further east.

A comparison between the temperatures and salinities in the table below, give a good idea of the changes which have occurred in the three months between April 28 and July 22, 1901.

Depth in Metres.	Amundsen. Stat. 3 Apr. 28, 1901		Knipowitsch. Stat. 537 July 22, 1901		Difference.	
	71° 33' N. 45° 30' E.		71° 18' N. 44° 12' E.			
	° C.	‰	° C.	‰	° C.	‰
0	-0.2	34.74	5.2	34.63	5.4	0.11
25	-0.23	.75	5.0	.61	5.23	.14
35	0.15	.81	3.65	.65	3.50	.16
50	0.40	.86	2.8	.69	2.4	.17
75	0.46	.89	1.8	.74	1.34	.15
100	0.48	.89	1.2	.76	0.72	.13
150	0.26	.90	1.1	.77	0.84	.13
200	-0.15	.92	1.0	.81	1.15	.11
215	-0.90	.90				
230			0.5	.81		

The upper 25 metres of water have become more than 5° C. warmer; in all depths there is a rise of temperature, and a fairly uniform decrease of salinity.

¹ *Loc. cit.*, Pl. 6, Fig. 9.

² *Loc. cit.*, Pl. 6, Fig. 4, and p. 22.

On a previous occasion¹ it was pointed out how the water-masses may be changed entirely in a very short time in this shallow sea, and how rapidly the very cold bottom-water may disappear under certain circumstances. At the „Fram's" Station 5 (*op. cit.*) in the Pechora Bay, on July 27 1893, there was a more than 53 metres thick bottom-layer of winter water with temperature below -1.5° C. and salinity about 34.5 ‰². But three weeks later Knipowitsch found no trace of it, 16 miles to the southeast.

*The cold and heavy Bottom-Water on the Coastal Shelf
of Novaya Zemlya.*

Nearly all sections across the Barents Sea, which reach the west coast of Novaya Zemlya, show very peculiar conditions over the shelf, outside this coast at depths between 120 and 150 metres. Over the floor of this shelf and in its depressions near the coast, there is generally, even in the autumn, a bottom-layer of water which has very low temperatures and unusually high salinities, frequently above 35.0 ‰. This bottom-water, which is much heavier than the water on the slope outside the shelf (see Figs. 2 and 3, pp. 26, 27), forms a layer which is thicker and with higher salinities early in the summer and spring than later in the season. It is obvious that this water, which is formed by cooling at the surface during the winter, owes its high salinity to the formation of ice on the surface, as is mentioned above (p. 31).

Amundsen's surface observations in the most eastern part of his route, over the coastal shelf (see Pl. I), show very clearly how the formation of ice appreciably increases the salinity of the sea surface and consequently also that of the underlying strata.

On May 31, 1900, Mr. Alf Wollebæk³ took, from on board the „Heimdal" of the Norwegian Navy, a vertical series of observations on the coastal shelf of Novaya Zemlya. Taken so early in the season as they were, these observations demonstrate better than any others hitherto, the formations of heavy bottom-water, and they will therefore be especially mentioned here. The water-samples were stored in soda-water-

¹ Oceanogr. of N. P. Basin, p. 262.

² This was obviously not a local occurrence, for at Stat. 6 on the following day, nearly 60 miles further to the east-south-east in the Pechora Bay, there were found similar low temperatures between 5 metres and the bottom at 22 metres.

³ Mr. Alf Wollebæk was sent out by Dr. Johan Hjort, leader of the Norwegian Fishery- and Marine-Investigations, to take oceanographic observations during the cruise of the „Heimdal" in the Arctic Sea, in May 1900.

bottles with patent india-rubber stoppers, and the possibility of evaporation was thus excluded. The specific gravity was carefully determined by my assistant Mr. Jakob Schetelig with a hydrometer of total immersion (made by C. Richter in Berlin, of Jena Glass No. 59^{III}, and tested at the Reichs Anstalt, Charlottenberg). The chlorine of the same samples were determined by Mr. Leivestad, who used for control Standard Water No. I, determined by Mr. Schetelig, by numerous observations with the Hydrometer of Total Immersion (see above p. 9). Some smaller samples were taken for titration in ordinary small bottles with cork-stoppers, and were determined by Dr. Heidenreich who used for control a Standard Water from Mr. Martin Knudsen in Copenhagen. His values on the whole agreed very well with those obtained by Schetelig and Leivestad but were not equally accurate. The values of specific gravity, salinity, and density have been computed by means of Knudsen's Tables¹.

	Depth in Metres.	Tempe- rature. ° C.	Leivestad by Titration.		Schetelig by Hydr. of Total Imm.		Δ S. ‰	σ_t
			Cl. ‰	S. ‰	σ_0	S. ‰		
Wollebæk	'0	—1'22		34'83 ²				28'04
Stat. II	10	—1'30	19'29	'85	27'995	34'84	+0.01	'05
May 31, 1900	20	—1'50	'295	'86	28'03	'88	—'02	'09
71° 48' N. Lat.	30	—1'52		'88 ²				'09
49° 38' E. Long.	50	—1'52	'30	'87	'03	'88	—'01	'09
	70	—1'65	'305	'88	'03	'88	'00	'10
	100	—1'65	'30	'87	'03	'88	—'01	'10
	120	—1'80	'455	35'15	'255	35'165	—'015	'33
	128	bottom						

It is a noteworthy fact that salinities as high as that of the sample from 120 metres, 8 metres above the bottom, have been observed nowhere else in the eastern Barents Sea. As before mentioned it is evidently due to the formation of ice at the surface in the same region during the previous spring or winter. It is very natural that water of

¹ The values are here only 0'11 ‰ lower than the values given in the Memoir on the Oceanography of N. Polar Basin, p. 273, although they ought to have been 0'16 ‰ lower (*cf. op. cit.*, Preface p. V). The reason is that by means of Knudsen's Tables the observations can now be more accurately computed than was then possible. It is also seen that the values now obtained for the sample from 120 metres by titration and Hydrometer of Total Immersion agree fairly well.

² Determined by Dr. Heidenreich.

this kind should be found just at this station where the observations were taken so early in the season. By intermixture with the overlying strata the salinity of this kind of bottom-water will be gradually lowered later in the summer.

This series of Wollebæk proves very clearly how the vertical circulation during the winter has been able to produce a perfectly uniform salinity between 20 and 100 metres. Near the surface, at 0 and 10 metres the salinity had been slightly lowered by the end of May, and the temperature of the upper strata had commenced to rise.

Later in the season these conditions are much altered, especially in the upper strata, as is seen by a comparison in the Table, p. 42, between Wollebæk's observations for May 1900, and Knipowitsch's observations in the same region for July and September of the same year¹ and also with later Russian observations in August, 1903 and 1904.

At Knipowitsch's Stations 249 and 345, in the region north and northwest of Wollebæk's Station II, there were in July and September hardly any traces left of the very cold and heavy water which Wollebæk had found a short distance to the south a month and a half before. There was only a very thin bottom-layer at Knipowitsch's Stations with temperatures about -0.6° C. and -0.5° C. The two salinities at Stat. 345 are very low (if they are trustworthy). These two Stations, especially No. 249, are near the edge of the coastal shelf, and are therefore near a region with more effective horizontal circulation. Stat. 10, Aug. 6, 1904, is also in this region, but on the slope in deeper water (205 metres and still farther towards the northwest. Here there is no trace of bottom water with temperatures below zero (10 metres above the bottom 0.5° C. and 34.79° ‰ was found) and although the Station is on the slope towards the deeper central depression of the sea, the salinity, which is rather uniform, is considerably lower than at Wollebæk's Station.

In the region to the south of the latter the conditions are very different, here, both at Knipowitsch's two Stations 247 and 248, in July, 1900, and at Breitfuss's Station 8 in Aug., 1903, and also at his Stats. 8 and 9 in Aug., 1904, well developed bottom-layers with low temperatures were found, but the layer is very much thicker at the three former Stations, than at those of 1904. For comparison may be included here the

¹ Cf. Knipowitsch, Expedition für Wissenschaftlich-Praktische Untersuchungen an der Murman Küste, vol. I, St. Petersburg, 1902, pp. 446, 482 (Russian with German Summary).

observations from the "Fram's" Stat. 3, on July 24, 1893, in the same region.

July 24, 93 71° 17' N. 48° 22' E.	Depth i Metres	0	20	40	60	80	100	120	130
	Temp. ° C.	3'69	2'91	-1'32	-1'64	-1'72	-1'63	-1 0	Bottom
	Salin. ‰	34'31	34'37	34'72		34'70	34'76	38'88	

The conditions were then more like those of July 1900, and Aug. 1903 than of August 1904, but the thick layer of bottom-water was colder than at any other time. The summer of 1904 has obviously been an exceptional year, in this region, with unusually high temperatures and low salinities especially in the upper strata.

All these stations are situated on the shallow platform southwest of Gooseland, and some of them (Stats. 247, 248, 8, and 9) are near the northwestern end of the submarine channel along the southern coast of Novaya Zemlya. It is evident that in this region the horizontal circulation along the bottom is very slow.

Breitfuss's Station 7 (Aug. 3, 1904) forms a most interesting exception from the others; there is no trace of the cold bottom-water, the temperature near bottom being 1'10° C. The explanation is probably that this Station is near the edge of the submarine valley extending eastwards into this region from the great central depression (see Fig. 1, p. 24). Along this valley there is evidently a more rapid horizontal circulation of warmer water from the Atlantic Current.

A striking fact borne out by a comparison between the above Stations is that the salinities at almost all depths, both north and south of Wollebæk's Station, are very much lower on August, 1903 and 1904, and also in September 1900, than they were on May 31, 1900. The difference is especially great near the surface, but it is considerable even in deep strata.

The observations made at the above Stations prove clearly that the cold bottom-water at the southern Stations cannot have been carried thither by a cold bottom-current along the coast, from the north, as some writers have been prone to believe. If such were the case it should be possible to find this water preeminently at the northern Stations. The unevenness of the bottom to the north would *a priori* make the existence of such a regular bottom-current in the shallow sea along the coast highly improbable. Local differences in the salinities of the bottom-water, also prove that this water does not form any regular bottom-current. And the vertical distribution of temperature and salinity

at Wollebæk's Station demonstrates better than anything else, that it is not a regular bottom-current, but more or less local phenomena that here have to be dealt with.

The same kind of cold, heavy bottom-water is found almost every where on the coastal shelf along the west and northwest coast of Novaya Zemlya, wherever a sounding has been taken. The many soundings taken by Dr. Breitfuss in August 1902¹, along the coast between 73° N. Lat. and 76° 29' N. Lat. (see Table above p. 22) are good examples. Everywhere below a depth of 25 metres cold bottom-water was found; a layer generally more than 100 metres thick, forming, as it were, a bank of heavy water over the shelf, with densities above 28.00 at depths greater than 50 metres (*cf.* Sections Figs. 2 and 3, pp. 26, 27). The great resistance offered to the horizontal movements of the water over the uneven bottom of the shelf, and the small depths, evidently protect this cold winter water from being entirely washed away in the summer, although, as was seen above, its salinity is gradually much reduced, and its temperature raised by intermixture with overlying waters. The following series of observations by Admiral Makaroff, in August 1901, is also interesting:

Stat. 57, Aug. 5, 1901 75° 1' N. Lat. 54° 55' E. Long.	Depth in m.	1	10	25	50	100	150
	Temp. ° C.	—1.8	—1.8	—1.8	—1.8	—1.8	—1.8
	Salin. ‰	33.526	33.526	34.458	34.94	34.97	35.044
	Salin. ‰	33.53	33.53	34.45	34.95	34.99	35.04

The water samples were taken in, green soda-water bottles with patent india-rubber stoppers (see about these samples below, p. 50). The upper series of salinities were determined by Mr. Jakob Schetelig with Hydrometer of Total Immersion and the lower series by Mr. Leivestad by Titration.

The cold Bottom-Water of the Central Depression of the Eastern Barents Sea.

A very prominent feature in all sections across the central depression (depths greater than 300 metres) of the eastern Barents Sea (see Fig. 1, p. 24) is the cold bottom-water with high salinity, rising, as it were, as a mountain of heavy water along the centre of this depression

¹ *Bull. d. Result. Courses Period.*, Aug. 1902, pp. 33—34.

(see the two sections reproduced on pp. 26—27, Figs. 2 and 3, see also Knipowitsch's section from July 1901¹) and Breitfuss's section from Aug. 1903². As was above pointed out, this cold bottom-water is, as a rule, separated from that on the coastal shelf of Novaya Zemlya by warmer water along the eastern slope of the depression (see all the sections mentioned above and the maps Pls. II, III³.) The isopycnals drawn for 27·90, 28·00 and 28·10, in Section Fig. 3 (p. 27), have very steep inclinations on the eastern slope of the depression, showing that the water there must be in rapid movement northwards along the slope. On the western slope the water is probably in movement southwards, but the movement is not so rapid. Knipowitsch's section from July 1901, and Breitfuss's section from August 1903, give very similar pictures, if the isopycnals be drawn.

In a short section from May, 1904, across the slope on the southern side of the depression (Fig. 4, p. 27), conditions quite similar to those on the eastern slope in the above section are to be found, but the inclination of the isopycnals for 27·90 and 28·00 is here much steeper, and indicative of a still more rapid movement of the warm waters along the slope eastwards. It is also apparent (as in other sections) that the isopycnals are again rising over the bank, inside the slope (see isopycnal for 27·90). In August, 1904, very nearly the same section was taken⁴; the waters at all stations were then very much warmer, and the salinities of the upper strata lower. The isopycnals, on the other hand, slope in exactly the same manner, although not so steeply, which indicates that the horizontal movement has been probably not so rapid near the surface, as it was in May. At the deepest station in August (Stat. 24, Aug. 21, 1904) there was very little cold bottom-water, but to judge from the depth (293 metres) this station was situated higher on the

¹ *Ann. Hydr. etc.*, 1905, Pl. 6, Fig. 5.

² *Bull. Result. Courses Period.*, Aug. 1903, Pl. V, Sect. Arct. II. The isohaline for 34·90 ‰ ought to be drawn differently in the central part of this section, more in accordance with the manner in which it is drawn in the section for Aug. 1904 (Fig. 3, p. 27). The isohaline should certainly form an elevation and not a depression near Stat. 11. The conditions have obviously been similar to those of Breitfuss's Section for Aug. 1902, reproduced here (Fig. 2, p. 26). There has been a "mountain" of cold water with high salinity in the middle and two masses of warmer water with high salinities near the bottom on both sides, especially on the eastern slope (Stat. 9).

³ Breitfuss's Section from Aug. 1902 along the southeastern part of the depression, forms an exception as was pointed out above (p. 25), but there have evidently been exceptional conditions on this occasion. There may have been a temporary displacement of water, similar to that proved by Amundsen's observations in April and May, 1901, in the region of his Stats. 9, 2, 10, and 3, see above, p. 36.

⁴ *Bull. Courses Period.*, Aug. 1904, p. 27, Stats. 24, 25, 26.

slope than Stat. 9 of May 15, 1904 (with a depth of 331 metres), and has therefore had comparatively more warm water.

In May¹ and August², 1903, very nearly the same section, with the same three Stations, was also taken. In August, 1903, the isopycnals slope in the same way as in August, 1904, indicating the same horizontal movement, but the waters were on the whole heavier and of lower temperature and higher salinity. The deepest Station (Stat. 26, August 28, 1903) is farther north and in deeper water than the Station 24, of Aug. 21, 1904. It is much more like Stat. 9, of May 15, 1904; but its bottom-water (between 150 metres and the bottom) is even colder and of higher salinity than at the latter station. In May 1903, the conditions were, however, very different — if the Latitudes and Longitudes of the stations be really correct. The water was then very much heavier at the two southern Stations (8 and 9, May 6, 1903) than at the deep northern Station (7, May 5, 1903) and also much heavier than the waters in the same region in May 1904. There has evidently been some displacement of the water masses in this year and perhaps an excessive cooling of the water. During the winter 1902—1903 and the spring 1903 there were on the whole exceptional conditions in these regions, as is known from other facts (*e. g.* the emigration of the seal (*Phoca groenlandica*) to the northern coasts of Norway).

In Breitfuss's section across the northern part of the depression, in Aug. 1902, Fig. 2 (p. 26), the isopycnals for 28.00 and 28.10, show on the whole an inclination towards the eastern slope but not to the same extent as in the above section further south (Fig. 3). This might indicate a less rapid movement which may be explained by the circumstance that we are here probably in a submarine valley extending eastwards (see Fig. 1, p. 24). The deep waters are here on the whole somewhat heavier over the slope than in the above section. The isohaline for 34.90 ‰ and the isotherms for 0.0° C. show, however, a very characteristic feature, namely, two bulks of warm water with comparatively high salinities obviously moving along the slopes to both sides of the depression, and on both sides of a "mountain" of cold water, in the middle, with salinity above 34.90 ‰. The warm water, with temperatures above zero, on the eastern slope, has on its long way northwards along this slope (see Pls. II and III, maps for 100 and 200 metres) been diluted by intermixture with overlying less saline strata, and had the salinity of its upper part reduced below 34.90 ‰.

¹ *Bull. Courses Period.*, May 1903, p. 212, Stats. 7, 8, 9.

² *Ibid.*, Aug. 1903, p. 28, Stats. 24, 25, 26.

The inclination of the isopycnals, as well as the distribution of temperatures and salinities in the different sections indicate that, as a rule, there is a cyclonic movement of the water in the central depression of the eastern Barents Sea (*cf.* maps Pls. II, III). This cyclonic movement is most rapid along the southern and eastern slope, whilst the water along the axis of the cyclone is comparatively stationary. Along the western side of the depression the cyclonic movement receives fresh supply of Atlantic water, coming from the west, especially along the submarine channels, in about 72° , $73^{\circ} 20'$, and $75^{\circ} 30'$ N. Lat. (*cf.* maps Pls. II, III) and therefore the salinities are frequently rather high on that side. On the north-eastern side of the cyclone comparatively warm water is given off towards the sea between Novaya Zemlya and Franz Josef Land (*cf.* the surface-temperature and salinities of the *Capella*, Pl. I, and the maps for 100 and 200 metres Pl. II, III). Along the axis of the cyclone, there will be comparatively favourable conditions for the formation of cold bottom-water by cooling at the surface during winter, as there is only little horizontal circulation. An effective vertical circulation may there be established between the surface and the bottom, with the formation of very cold water having a comparatively high salinity. But as the depth is so great, it cannot be expected that the formation of ice during the winter will increase the salinity of the sea-water by so much as it does in the shallow water over the coastal shelf of Novaya Zemlya; and unusually high salinities near the bottom, such as might be found in the latter region (*cf.* Wollebæk's Stat. II) are not to be expected.

In Breitfuss's section for August, 1902 (Fig. 2, p. 26), the bottom-water with temperatures below -1° rises very near the surface (about 35 metres below the surface) in the central part of the depression at his Stat. 63 (Fig. 1). Some time in the previous winter or spring there would probably have been found, somewhere in this region, nearly homogeneous water with temperatures of about -1.4° C. and salinity about or above 34.9 ‰ between the surface and the bottom. The conditions seem to be strikingly like those found in the region of Amundsen's Stations 13—23, east of Northern Greenland as will be described in the next chapter. The form of the isotherm of -1° C. is, for instance, almost the same at Amundsen's Stat. 16 (see Section IX, Pl. X) as it is here at Breitfuss's Stat. 63.

Amundsen's surface observations seem to indicate, that even on the southwestern side of the Central Hollow of the eastern Barents Sea, there may be the necessary conditions for the formation of cold bottom-water.

Between May 26 and 31 (see Table I), in about 73° N. Lat. and between 38° and 40° E. Long., Amundsen found the sea-surface cooled to about its freezing point, whilst the surface-salinities were about 34.7 or 34.8 ‰. The surface-water had consequently a density *in situ* of between 27.96 and 28.05, and it seems therefore that a vertical circulation reaching down to the deep cold layers might easily be possible in this region.

From the places where the cold winter water is chiefly formed, it spreads as heavy underlying water along the deepest central part of the depression, and forms its bottom-layers. Only where the water is in rapid horizontal movement along the slopes, is the level of the underlying cold heavy water lowered by the pressure produced by this moving water, which is deflected, by the Earth's rotation, against the slopes and against the heavy water on the banks. The cold underlying-water will therefore rise highest along the central portion of the depression.

This cold heavy bottom-water will, however, probably also creep westwards along the bottom of the deepest channels communicating with the depression; and being deflected by the Earth's rotation, it will chiefly move westwards along the northern slope of these Channels (*cf.* maps Pl. III). There is therefore found the same kind of cold bottom-water forming a layer 140 metres thick near the bottom (between 150 and 290 metres), at Amundsen's Stat. 12, on the northern side of the central channel (in $73^{\circ} 50'$ N. Lat., $37^{\circ} 50'$ E. Long.)¹. His Stat. 11 is on the southern side of the same channel and here there is also cold bottom-water in 275 and 300 metres, but it is not possible to say how thick the layer may have been.

About 130 kilometres (70 naut. miles) further west, Knipowitsch has a section across the same channel, five or six weeks later in the same summer². Here there is the same cold water, as at Amundsen's Stat. 12, with temperatures below -1° C. and salinity below 34.90 ‰, forming a thin layer along the bottom on the northern slope of the channel, at Stats. 503, 504, and 505 (between $74^{\circ} 15'$ and $74^{\circ} 45'$ N. Lat. and along the meridian of $33^{\circ} 30'$ E. Long., see maps Pls. III and V). It is thickest at the most northern Station, as might be expected owing to the deflecting force of the Earth's rotation. In sections further west, near the eastern end of the deep channel south of Bear Island, this cold

¹ The observations at the Russian Stat. 21, on Aug. 19, 1904, which is very near Amundsen's Stat. 12 (see Figs. 1 and 3, pp. 24, 27), seem to prove that the conditions may differ much in this region. As is seen in the Section Fig. 3, there is hardly any cold bottom-water at Stat. 21, and temperatures as well as salinities are very different from those of Amundsen's Stat. 12.

² *Ann. Hydr. etc.* 1905, Pl. 6, Fig. 2.

bottom-water is found no more; it gradually mingles with the overlying warmer water; and has thus no communication with the cold bottom-water of the Norwegian Sea. It is nevertheless interesting to notice how similar Amundsen's bottom-water at Stat. 11 (with about -1.4°C . and 34.93‰), is to the bottom-water he found in the Norwegian Sea east of Greenland (about -1.3°C . and 34.92‰). It shows how cooling at the sea-surface during the winter, may produce, by the same process, very similar results in very different regions, and in seas with very different depths.

The bottom-water of the central hollow of the eastern Barents Sea may, however, have very different temperatures in different years. In July 1899, its temperature was about -1.8 or -1.9°C . (Knipowitsch's Stations 68—70¹, in about 73° and 72° N. Lat., and $39^{\circ} 12'$ and $40^{\circ} 38'$ E. Long.).

In July (10) and September (28), 1900, the temperature in the deepest central part of the hollow was about -1.3 and -1.5°C . (Knipowitsch's Stations 254 and 365²).

In July and August, 1901, the bottom-temperatures seem to have been about -1.4 or -1.5°C . according to Knipowitsch's sections³.

In August 1902 the bottom-temperature was in all parts of the central hollow about -1.3 and -1.4°C . (see Table above, p. 22).

I May and August, 1903, it was about freezing point, -1.85 and -1.8°C . (see Table above, p. 22).

I May and August, 1904, it seems to have been about the same, -1.8 and -1.75°C . (see Table, p. 22).

The salinity seems to be very frequently about 34.94 (cf. 1903 and 1904), and to be fairly uniform for the bottom-water of the whole of the Hollow, at least in the same year. But a thin bottom-layer has often salinities above 35.0‰ .

Possibility of communication between the cold Bottom-Water of the Northeastern Barents Sea and that of the North Polar Basin.

There is much similarity between the salinity of the heaviest bottom-water of the eastern and northeastern Barents Sea, and the salinity of the bottom-water of the North Polar Basin, according to the values

¹ Knipowitsch, Exp. für wissenschaft.-praktische Untersuchungen an der Murman Küste, vol. I, pp. 322—323.

² *Ibid.* pp. 448, 482.

³ *Ann. Hydr.* etc. 1905, Pl. 6, Figs. 5 and 3.

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obtained by a new revision of the observations (see below, last chapter). But the lowest temperature of the latter is nearly one degree Centigrade higher than the lowest temperature of the former¹.

A question of much interest for our later discussion, is: whether it is in any way possible, that bottom-water found in the Barents Sea, or in the region to the north-east, may flow into the North Polar Basin? According to my bathymetrical chart of the North Polar Seas² (see also Fig. 1, p. 24) there seems to be a channel, more than 300 metres deep, coming from the North Polar Basin and running southwest between Novaya Zemlya and Franz Josef Land³, but, as my bathymetrical chart of the Barents and Kara Seas⁴ shows, this channel hardly communicates with the deep central depression of the eastern Barents Sea, from which it seems to be separated by a barrier rising nearly to about 200 metres below the surface.

When Admiral Makaroff started on his expedition with the Yermak in 1901, he took a Pettersson-Nansen Water-Bottle with him (delivered by L. M. Ericsson i Stockholm), and some Nansen Deep-Sea Thermometers, from Richter in Berlin. He was also kind enough to take some green soda water-bottles, with patent india-rubber stoppers, which the writer sent him, for holding the water-samples; and he sent the bottles with samples back after his return⁵. The specific

¹ Professor Otto Pettersson says that, "this cold and salt bottom-layer (of the eastern Barents Sea) is evidently an updrift from the depths of the Polar Sea, which enters from north and north-east both into the Kara and the Barents Sea". (*Geograph. Journal*, London, vol. XXIV, 1904, p. 314). It is not quite clear what Prof. Pettersson means, for there is, as the expedition with the Fram proved, no bottom-water with such low temperatures in the North Polar Basin, and Pettersson cannot mean that the bottom-water should become colder on this way, under warmer water. But even if such water really existed in the depths of the North Polar Basin, it seems difficult to imagine what kind of force may exist to lift this unusually heavy water from the bottom of that deep sea up to the level of the bottom of the Barents Sea, or even to a level of 120 metres below the surface (at Wollebæk's Station), or even to only 70 metres at the Station 4 of the Fram-expedition (off Gooseland, 1893).

² Nansen, *Norwegian N. Polar Exp. 1893-1896, Scientific Results*, vol. IV, No. 13, Pl. 1.

³ As stated, *op. cit.* p. 16, it was Admiral Makaroff's valuable soundings in the sea between Novaya Zemlya and the Franz Josef Archipelago, and east of the latter, especially his temperatures and water-samples, which pointed to the conclusion that this channel communicates with the North Polar Basin. Dr. N. Knipowitsch, who is publishing Makaroff's observations, has independantly come to the same conclusion (*Revue Internationale de Pêche et Pisciculture*, 1903, No. 2-3, published before the writer's memoir). Makaroff's soundings now published in the sections given by Knipowitsch (*Ann. Hydr. u. Marit. Meteor.* 1905, Pl. 6, Figs. 6-8) make this assumption still more probable.

⁴ *Op. cit.* Pl. II.

⁵ The bottles had for days been washed out i hot water, before they were sent, and the patent stoppers prevented all possibility of evaporation. As, however, Makaroff did not

gravity of the samples thus taken was carefully determined by Mr. Jakob Schetelig with the Hydrometer of Total Immersion. The salinity was determined by Mr. Leivestad, by Titration (Mohr). The values obtained by the two methods agree on the whole very well, as is seen in the Table below. Makaroff's values thus obtained, may consequently be assumed to be very accurate, and are in several respects important¹. The results of the determinations of the samples from this part of the sea are therefore here given in detail.

Station and Locality	Depth in Metres	Tempe- rature <i>in situ</i>	σ_0 by Hydro- meter of Tot. Imm.	S ‰			σ_t
				by Hydrom. of Tot. Imm.	by Titra- tion	Δ	
Stat. 77, Aug. 15, 1901 78° 21' N. Lat. 61° 15' E. Long.	0	0.4° C.	27.313	33.986	34.03	+0.044	27.29
	10	-0.1 "	.385	.080	.11	+ .030	.39
	25	-1.6 "	.613	.366	.38	+ .014	.68
	50	-1.9 "	.784	.574	.58	+ .006	.86
	100	-1.9 "	.838	.646	.66	+ .014	.91
	150	-1.0 "	.876	.693	.71	+ .017	.92
	200	0.0 "	.990	.83	.85	+ .020	.99
	300	-0.1 "	28.033	.883	.88	- .003	28.04
Stat. 78, Aug. 15, 1901 79° 4' N. 61° 17' E	25	-0.7° C.	27.618	34.368	34.39	+0.022	27.58
Stat. 82, Aug. 16, 1901 80° 26' N. Lat. 64° 14' E. Long.	10	-0.5° C.	27.300	33.97	34.03	+0.060	27.32
	25	-1.0 "	.570	.34.31	.34	+ .030	.61
	50	-1.7 "	.765	.55	.60	+ .050	.86
	100	-1.7 "	.833	.636	.63	- .006	.89
	200	-0.9 "	.933	.763	.76	- .003	.975
Stat. 83, Aug. 16, 1901 79° 45' N. Lat. 65° 9' E. Long.	250	0.6 "	28.055	34.912	34.92	+0.008	28.021
	300	0.7 "	.065	.924	.93	+ .006	.025
	350	0.5 "	.063	.921	.95	+ .029	.035

Makaroff's Stations 77, and 83 are evidently in the channel or depression communicating with the North Polar Basin² (see Fig. 1, p. 24). Here at depths about or greater than 200 metres, there is warm water

trust these simple green bottles, he also sent some other samples, taken simultaneously, in very fine glass-bottles with glass-stoppers; but these samples gave all of them higher salinities, indicating that evaporation had taken place.

¹ Cf. N. Knipowitsch, *Ann. der Hydr. u. Marit. Meteorologie*, 1905 (Reprint p. 27); and *Revue Internationale de Pêche et de Pisciculture*, 1903, No. 2-3.

² Cf. Knipowitsch, *Ann. Hydr. etc.*, 1905, pp. 254-255.

of exactly the same kind as was found during the Fram Expedition in the North Polar Basin, and the salinities are not much below the values obtained for similar depths in the latter, by a revision of the observations (see below, last chapter)¹. The upper boundary of the water with temperatures above zero, seems to be in about 200 metres at Makaroff's Stat. 77, and at similar depths at his Stations 84 (where it is somewhat higher), 83 *bis*, and 83 (where it was somewhat lower)². This corresponds remarkably well with the conditions in the North Polar Basin, where the isotherm for 0° C. is in depths about 200 metres (between 165 and 240 metres)³. The sections through Makaroff's stations, published by Dr. Knipowitsch, show a remarkable feature. The warm intermediate or bottom-water, with temperatures above zero, is only found at Stations 77 and 84 (see Fig. 1, *M* 77, *M* 84, p. 24), on the northern side of the submarine valley coming from the northwest, whilst at Makaroff's Stations 7 and 85 (Fig. 1, *M* 7, *M* 85) on the southern side of this valley there is much colder water (see maps, Pl. III). At Station 7 there is a maximum, with temperature above -1° C., between 130 and 225 metres⁴ (see map for 200 metres Pl. III). The explanation obviously is, that there is here a kind of cyclonic movement; warm water at depths greater than 200 metres on the northern side of the channel could not be thus limited to one side only, unless in movement southwestwards along the northern slope of the channel. The cold water of the southern slope (Pl. III) is moving in

¹ For comparison may also here be added the determinations of some samples brought home by Dr. Blessing from Fram-Stat. 24. As to the trustworthiness of these samples see below (last chapter).

	Depth in Metres	Tempe- rature <i>in situ</i>	S ‰ Accurate Determina- tions with Pycnometer	S ‰ Less trust- worthy Deter- minations	σ_t
Stat. 24, of the Fram- Expedition Nov. 30 and Dec. 2, 1895	150	-1°35' C.	34°42		27°68
	200	0°11	34°74		27°91
	250	0°57	34°88		28°00
85° 28' N. Lat.	450	0°73		34°96*	28°05
58° 45' E. Long.	550	0°55		34°96*	28°06
	800	0°15	34°99		28°11
	850	-0°01	35°01		28°14
	900	-0°04		34°97	28°11

The salinities marked with an *asterisk*, for 450 and 550 metres, are taken from Dr. Blessing's observations with the hydrometer, as they are more trustworthy than those taken by Dr. Heidenreich with Pycnometer (see *Oceanography of N. P. Basin*, p. 213). The values of salinity are computed by Knudsen's Tables.

² Cf. Knipowitsch, *loc. cit.* Pl. 6, Figs. 7, 8.

³ See *Oceanography of N. P. Basin*, Pl. XV.

⁴ Cf. Knipowitsch, *loc. cit.* Pl. 6, Fig. 7.

the opposite direction, perhaps coming from the Barents Sea; and both waters are deflected against the slopes by the Earth's rotation. The water with a maximum above -1° C. at Makaroff's Station 7, is probably the same kind of water which is seen at Makaroff's Stat. 67 (Fig. 1), at about 100 metres, with a maximum about 0° C. (Pl. II). This water is obviously a branch from the warm intermediate water found at Breitfuss's Stations 60, 61, and 62, in his section to the southwest¹ (see Fig. 2, p. 26). This water is probably moving northeastwards along the right-hand side of the valley, being more and more cooled on the way by intermixture with the surrounding colder water. It is seen that this warm water is lying higher, about 100 metres, than the warm intermediate water of the North Polar Basin. At Stat. 7 it has nearly disappeared (see map for 100 metres Pl. II, and for 200 metres Pl. III) and the maximum has been lowered to greater depths, as the upper part of the warm water has been more cooled by intermixture with the overlying cold waters.

It is a remarkable fact that in the northern part of Makaroff's most western section in this region, published by Knipowitsch², there are also traces of the intermediate warm water of the North Polar Basin, but the temperature of this water is here lowered to between -0.3 and -0.8° C. It forms a bottom-layer at the Stations 61, 62 and 66 (see Fig. 1, *M* 61, *M* 62, *M* 66, p. 24) which, however, in this enclosed submarine valley³, has no very open communication with the warmer water of the submarine valley to the east (Stats. 77 and 84), and from which it may possibly be separated by a ridge preventing the warmest water of the latter stations from flowing westwards. It is, however, noteworthy that also in this section the warmer bottom-water does only occur in the northern part of the section, and is distinctly separated from the intermediate warm water coming from the Barents Sea, in the southern part, which rests on very cold bottom-water with temperatures below -1.5° C. The latter may probably be moving along the slope northeastwards. It is very unfortunate that no samples of this cold bottom-water were brought home, and its salinity is therefore

¹ There is probably a ridge between the depression of Breitfuss's section and that of Makaroff's Stats. 67 and 60, which prevents the warm water, below 200 metres, from flowing northeastwards.

² *Loc. cit.* Pl. 6, Fig. 6.

³ It may also be possible that this valley communicates with the North Polar Basin to the north through a channel southwest of Franz Josef Land, and that the warmer bottom-water has come that way, being gradually cooled by intermixture with colder water.

unknown. But it does not seem improbable that it is of the same kind as the cold bottom-water of the northeastern Barents Sea, perhaps similar to that of the northern coastal shelf of Novaya Zemlya. It may therefore be possibly that bottom-water of this kind may sink along the bottom into the deep North Polar Basin.

Another question is whether cold bottom-water may actually be formed by vertical circulation in this same region during the winter?

Makaroff's overlying cold water-stratum between 0 and 200 metres (Stats. 77, 78, 82) has, on the whole, a much higher salinity than it has farther north, in the North Polar Basin, and also higher than at Amundsen's Station 24 and 25 in the northwestern Barents Sea. This may be due to the fact that Makaroff's Stations are in the region which receives water from the Atlantic Current of the Barents Sea¹. During the winter and spring the salinity of this overlying water may be still more increased by the formation of ice, and by the vertical circulation caused by radiation of heat from the surface during the long winter. As the salinities are so much higher than in the North Polar Basin, the vertical circulation may go much deeper than was found to be the case on the Fram Expedition. But still it seems hardly probable that it should be able to penetrate the thick upper layer, with low salinities, at Makaroff's Stats. 77 and 82, in an open sea where there is probably a fairly rapid horizontal circulation. The question still remains open, however, whether in the region nearer Novaya Zemlya there may not be higher salinities near the sea-surface, at least sometimes during the winter, especially if there be little horizontal circulation, and the sea be shallow, an excessive ice-formation with heavy ice-pressures may there produce bottom-water of comparatively high salinity (above 35.0 ‰) and temperatures about -1°C. (or -0.9°C.) like that of the North Polar Basin. It was seen above that very cold bottom-water with high salinity is formed under similar conditions in the eastern and northeastern Barents Sea, although the same region of the sea was always covered with thick surface-layers of low salinity, between 33.0 and 34.5 ‰, whenever it has been examined in the summer.

It is a very important fact that according to the observations of Captain Stokken of the *Capella*, there was comparatively warm surface water with salinities of as much as 34.50 and even 34.60 ‰, in July, 1901, in the very region of Makaroff's Stats. 60 and 61,

¹ See Knipowitsch, *Ann. Hydr. u. Marit. Meteor.*, 1905, Pl. 7. See also the surface observations of Capt. Stokken, of the *Capella*, July, 1901, Pl. I.

between 77 and 79° N. Lat. and between 49 and 54° E. Long. (see Pl. I). If water with a salinity of 34.58 ‰ be cooled down to its freezing-point it will get a density of about 27.86.

Polar Surface Water of Northern Barents Sea.

Amundsen's Stations 24 and 25 (Table II), between King Charles Land and Northeast Land (Spitsbergen) and south of King Charles Land, are interesting because they show that this part of the Barents Sea is covered by a surface layer of cold polar water which is very similar to that of the North Polar Basin, except that the salinities at Amundsen's stations were on the whole higher. Below are the observations at one of the stations taken during the drift of the Fram across the North Polar Basin (Stat. 23) for comparison with Amundsen's station. The Fram salinities have been recalculated by means of Knudsen's Tables from Blessing's determinations with the hydrometer. Also included for comparison are determinations for one of the Russian stations (Stat. 32) from the cruise in August 1902, and Makaroff's two Stations 77 and 82.

Depth in Metres.	Fram, Stat. 23 July 31, 1895 84° 28' N. Lat. 75° 56' E. Long.	Amundsen's Stat. 24 Aug. 20, 1901	Amundsen's Stat. 25 Aug. 27, 1901	Russian Stat. 32 Aug. 1902 75° 27' E. Lat. 43° 45' E. Long.	Makaroff's Stat. 77	Makaroff's Stat. 82
0	0.16° C. 31.53 ‰	1.7° C. 33.03 ‰	1.3° C. 33.69 ‰	2.71° C. 33.91 ‰	0.4° C. 33.98 ‰	
20	-1.79° C. 32.18 ‰	0.3° C. 34.07 ‰				
25		-1.16° C. 34.28 ‰	0.13° C. 33.95 ‰	-0.72° C. 34.38 ‰	-1.6° C. 34.36 ‰	-1.0° C. 34.31 ‰
40	-1.88° C. 33.32 ‰	-1.63° C. 34.13 ‰				
50			-1.17° C. 34.21 ‰	-1.25° C. 34.69 ‰	-1.9° C. 34.57 ‰	-1.7° C. 34.56 ‰
60	-1.88° C. 33.70 ‰	-1.94° C. 34.50 ‰	-1.17° C. 34.31 ‰			
80	-1.86° C. 34.03 ‰	-1.92° C. 34.49 ‰	-1.25° C. 34.37 ‰			
100	-1.78° C. 34.22 ‰	-1.80° C. 34.53 ‰	-1.35° C. 34.31 ‰	-1.11° C. 34.81 ‰	-1.9° C. 34.65 ‰	-1.7° C. 34.63 ‰
120	-1.59° C. 34.29 ‰					
125		-1.51° C. 34.59 ‰				
140	-1.48° C. 34.32 ‰					
150		-1.79° C. 34.61 ‰			-1.0° C. 34.70 ‰	
160	-0.82° C. 34.65 ‰					

Amundsen's salinities lie between those of the North Polar Basin, and those at the Russian Station in the Barents Sea to the southeast as well as those of Makaroff's Stations to the east. It seems probable that Amundsen has been in Polar water coming from the northeast through the strait between the Franz Josef Archipelago and Spitsbergen. The salinity of this Polar water is gradually increased on the way southwards by intermixture with southern waters of higher salinity.

V. The Waters of the Northern Norwegian Sea and the East Greenland Polar Current.

Capt. Amundsen's observations at the eleven Stations (13—23, Table II) in the sea north of Jan Mayen and east of Greenland, are especially valuable; for they present very graphically the manner of formation of the Bottom Water in the Norwegian Sea. This water fills the whole basin everywhere below a depth of, say at least 1000 metres; it forms at least two thirds of its bulk of water. During the cruise with the Michael Sars in 1900 it was discovered that this bottom-water has a remarkably uniform salinity varying slightly between 34·89 and 34·92 or 34·93 ‰¹. Its temperature varies slightly between $-1\cdot1$ and $-1\cdot3^{\circ}$ C. in the deepest strata near the bottom, and rises extremely slowly upwards into the higher strata. It has generally been assumed that this cold bottom-water was of Polar origin and derived from the East Greenland Polar Current. On an earlier occasion² the writer has already pointed out that observations prove that this cannot be the case; this bottom-water must be formed on the surface of the sea in the very region of Amundsen's Stations, and in fact by cooling of the water through radiation during the winter.

This is clearly seen, if Amundsen's observations be compared with those of other expedition in neighbouring regions. Unfortunately no other deep-sea observations were taken in these tracts during the summer of 1901, and it is, therefore, necessary to use those taken during earlier years, by various expeditions. As the distribution of temperature and salinity may no doubt vary much from one year to another, it cannot be expected that a very accurate picture of the distribution at a particular moment will be obtained by comparing observations from different years; but still it may be assumed that certain well marked and general features, of both vertical and horizontal distribution, prevail in most years, and it

¹ As was already mentioned above, p. 12, it makes a difference whether the salinity of this bottom-water be computed from the Specific Gravity, or from the amount of Chlorine, (as found by Titration).

² F. Nansen, Oceanography of the North Polar Basin. *The Norwegian North Polar Expedition 1893—1896. Scientific Results*, Vol. III, No. 9, 1902, p. 416.

is probable that these features may be made out by studying critically the material at hand.

The following expeditions have made observations which may be valuable from this point of view.

The *Norwegian North Atlantic Expedition*, on board the *Vöringen* took a great many Stations in the region east and northeast of Amundsen's Stations, in July and August, 1878. The *temperatures*, given by Prof. Mohn¹ seem to be fairly trustworthy wherever they have been gradually decreasing from the surface downwards, but where, in the upper water-strata, a warmer layer has been placed under a colder one, a feature very characteristic for Arctic waters, the instruments used have not given trustworthy results, and frequently have even failed to indicate the existence of such warm layers, which are now known to exist. The reversing apparatus used, a wooden case, did not give the Negretti and Zambra thermometers a sufficient time for assuming the correct temperature, since the instruments were frequently reversed as soon as they reached their proper depth, and the readings obtained were therefore more or less due to the temperature of water-strata through which the thermometers had passed on their way down, and not so much the actual temperature at the depth recorded. The other thermometers used during the expedition have evidently not been suitable for measuring accurately the temperatures of such intermediate warm water-strata. Mohn's curves, representing the vertical distribution of temperature, have, at many Arctic Stations (*e. g.* Stations 226, 297, 298, 300, 304, 350, 351, 352), indications of the typical warmer water-stratum underlying the cold Polar layer near the surface, but it must be assumed that the temperatures of this particular warm stratum are in most cases too low. It is therefore often somewhat difficult to use the temperatures for comparison with more accurate observations. The *salinities* or *specific gravities* obtained for deeper water-strata during this expedition, are not sufficiently trustworthy for the present purpose.

Captain C. Ryder², on board the *Hekla*, took in July 1891, a series of very important Stations (R VIII—R XIII, Pl. V), across the East Greenland Polar Current, north of Amundsen's Stations. Ryder's temperatures were taken with Negretti and Zambra Reversing Thermometers, and are evidently fairly good. But the values of salinity are not

¹ H. Mohn, *The North Ocean. its Depths, Temperature and Circulation, The Norwegian North-Atlantic Expedition, 1876—1878*, Christiania, 1887.

² C. Ryder, *Den Østgrønlandske Expedition, 1891—92, Meddelelser om Grønland*, vol. XVII, Copenhagen, 1895, pp. 189 *et seq.*

trustworthy, for on the one hand the determinations by Mr. K. Rørdam of specific gravity and chlorine are obviously very inaccurate¹, and on the other hand the water-bottle used, has obviously not closed tightly.

The *Danish Ingolf Expedition* in 1895—1896 made some very valuable oceanographic work in the waters round Iceland, and between Iceland and Jan Mayen², which have been used for constructing the oceanographic charts (Pl. V) of this part of the sea. The temperatures were taken with Reversing Thermometers from Negretti and Zambra, and also by some of Knudsen's own construction. The thermometers were carefully controled, and the temperatures appear to be very trustworthy. The salinities obtained during this expedition are, however, not sufficiently accurate for the present purpose. There are sometimes great irregularities in the series, which are evidently erroneous; they must probably be ascribed to the water-bottle (Sigsbee Water-Bottle) which has not been reliable: in this manner the much too low salinities may in many cases, be explained. But the salinities are frequently also too high, as is best seen where samples have been taken from the deep cold strata which in many cases gets a much too high salinity, even after the values have been reduced by 0.05 ‰, in order to make them comparable with those of M. Knudsen's Tables.

At the request of O. Pettersson and G. Ekman, Professor S. Arrhenius took, on board the *Virgo* of the *Andrée Expedition*, a series of Stations (Arr. I—VI, Pl. V) west of Northern Spitsbergen. The water-samples as well as the temperatures were taken with a Pettersson Insulated Water-Bottle. The results of the observations are described by O. Pettersson and G. Ekman³. The thermometer was inserted after the bottle came up, which is apt to make the determinations of temperature inaccurate, and besides, the insulation of the water-bottle has not been sufficient for the greater depths, or the releasing arrangement of the water-bottle has not worked properly; for the temperatures obtained, are very improbable in several cases, especially for 850 metres (Stats. IV and VI). The salinities are also somewhat irregular and obviously erroneous in several cases. According to the values of tempe-

¹ Cf. Nansen, Oceanography of N. P. Basin, p. 407.

² Martin Knudsen, Hydrography, *Danish Ingolf-Expedition*, vol. 1, No. 2, Copenhagen, 1898.

³ O. Pettersson, G. Ekman, and P. T. Cleve, Die Hydrographischen Verhältnisse der oberen Wasserschichten des Nördlichen Nordmeeres zwischen Spitzbergen, Grönland und der Norwegischen Küste, 1896 und 1897, *Bihang till K. Svenska Vet.-Akad Handlingar*, vol. 23, Sect. II, No. 4, Stockholm, 1898.

ratures and salinities given, heavier water should frequently have been placed on top of much lighter strata; but it is often impossible to decide whether the errors are chiefly due to errors in the temperature or in the salinity¹. The values of the latter have been determined from the amount of chlorine per litre, and have to be reduced by about 0.07 ‰ ² to be comparable to the salinities found from Knudsen's Tables³. The highest salinity obtained at Arrhenius's Stations was 35.22 ‰ (originally 35.29 ‰), at 400 metres (Stat. IV), but this is evidently erroneous, if the temperature of 2.46°C. given for the same depth be correct. For the density of that water-stratum would then have been 28.14 , and much heavier than all underlying waters. If the temperature be correct the salinity must have been less than 35.17 ‰ , but if the salinity be correct, which is improbable, the temperature must have been above 3°C.

The Nathorst Expedition to East Greenland took, in June and July, 1899, a few Stations (*N* VI—*N* IX, Pl. V), in the region between Amundsen's Stations (20 and 19), and the Greenland coast. The results are described by Mr. Filip Åkerblom⁴, the oceanographer of the expedition. The temperatures were taken usually by a Pettersson Insulated Water-Bottle of the old form. The thermometer was inserted after the bottle came on deck and cannot therefore be expected to give perfectly accurate temperatures; but as the depths were not great these temperatures may be expected to be very satisfactory. For depths greater than 500 metres reversing thermometers were used, the accuracy of which were inside the limits of 0.1°C. , according to repeated experiments. The salinities given by Åkerblom appear, however, to be less trustworthy. Åkerblom gives in his tables the amount of chlorine per litre at 15°C. , but he says that salinities are computed

¹ The latter errors may have been due to evaporation of water through the cork-stoppers of the sample bottles on the way home.

² Mr. B. Helland-Hansen informs the writer that values of salinity computed from the amount of Chlorine by means of the tables formerly used in O. Pettersson's laboratory, are about 0.08 or 0.09 ‰ higher than those obtained by Knudsen's Tables. If however the salinity be computed from the permillage of Chlorine (per 1000 grams seawater) by means of the factor 1.809 the value obtained will be nearly 0.05 ‰ higher than that obtained by Knudsen's Tables. A reduction of 0.07 ‰ as a mean between the two, has here been employed.

³ Pettersson himself does not seem to be aware of this fact as he has recently compared the old values of salinities from Arrhenius's Stations with those found in the North Polar Basin. He reduced the latter salinities but does not reduce the former (see *Geograph. Journal.*, London, vol. XXIV, 1904, p. 316).

⁴ Filip Åkerblom, *Recherches Océanographiques. Expedition de M. A. G. Nathorst in 1899. Upsala Universitets Årsskrift 1903. Matematik och Naturvetenskap*, II, No. 1, Upsala, 1904.

according to Martin Knudsen's tables. On the whole he seems to have got somewhat high salinities, but it is difficult to decide how much his values ought to be reduced. If his salinities found for the bottom-water of the Norwegian Sea, be taken it is found that his errors vary much, as the following examples will demonstrate. It is known now that the bottom-water with a temperature of about -1°C . has a salinity of about 34'92 ‰ and 34'93 ‰. If the latter value be assumed as the upper limit, the following minimum errors for Åkerblom's determinations of the bottom-water will be obtained.

Number of Station	Depth in Metres	Temperature	Salinity	Minimum Error
II	667	$-1^{\circ}0^{\circ}\text{C}$.	34'97 ‰	+ 0'04 ‰
III	1916	$-1^{\circ}1$	34'96 "	+ 0'03 "
V	2000	$-0^{\circ}9$	34'94 "	+ 0'01 "
VI	500	$-1^{\circ}3$	35'01 "	+ 0'08 "
V:a	1028	$-0^{\circ}8$	35'16 "	+ 0'23 "

The probability seems to be that, at least, some of those errors are due to evaporation through the cork-stoppers of the glass-bottles in which the water-samples were brought home. The values 34'97 and 34'99 ‰, for the salinity at 100 and 150 metres, Stat. *N* VI (see Sect. VI, Pl. VIII) and at 200 and 270 metres, Stat. *N* VII (see Sects. V and VII, Pls. VII, IX) are obviously also too high, and have to be reduced by perhaps about 0'06 or 0'08 ‰.

Captain G. Amdrup¹ took in June and July, 1900, three Stations (*A*p II—*A*p IV, Pl. V) between Jan Mayen and Greenland. Both temperatures and salinities were taken with a Pettersson Insulated Water-Bottle of the old pattern at Stations II and III, and partly Station IV. As the temperatures were taken by means of a thermometer which was inserted after the water-bottle came on deck, they cannot be very accurate, but they, as well as the salinities, are evidently very good. The values of the salinity are, however, obviously somewhat too high, on the whole, and give too high densities, if they be compared with those of Amundsen's Stations. The densities of the deepest water-strata at his Stat. II, northwest of Jan Mayen, are also too high, if they be compared with those of the Michael Sars, taken in the neighbourhood in the same summer (see Sect. IX, Pl. X). At his Stat. III (see Sects. IV, VI, VII) Amdrup has obtained samples from the typical bottom-water with

¹ G. Amdrup, Carlsbergfondets Expedition til Øst-Grønland, 1898—1900, *Meddelelser om Grønland*, vol. XXVII, Copenhagen, 1902, pp. 345—349.

temperatures below zero centigrade (at 200, 220, and 250 metres) but his salinities are obviously about 0.04 ‰, too high; they have here been reduced accordingly, and the values thus obtained agree very well with those of Amundsen's Stations. At Station IV, Amstrup also used a Sigsbee Water-Bottle and a reversing thermometer; but he himself points out that these instruments have possibly not worked satisfactorily; both temperatures and salinities seem improbable, which is also indicated by the densities; it was therefore thought advisable to leave these observations out of consideration.

During the *Kolthoff Expedition*, on board the *Frithjof*, to the East Greenland Coast, Mr. Östergren¹ took, in July 1900, two interesting Stations (*F I* and *F II*, Pl. V) with deep-sea observations to the north of Jan Mayen and between Spitsbergen and Greenland. The temperatures were taken with a Pettersson-Nansen Insulated Water-Bottle, of the first model made by L. M. Ericsson & Co. in Stockholm, in 1900; but without the Nansen Deep-Sea Thermometer. The temperature readings were taken by a thermometer inserted after the water-bottle came on deck, which prejudices the accuracy of the observations. Nor is it stated whether any correction has been introduced for the reduction of temperature caused by alteration of pressure. It is stated that the bottle was hauled up with a velocity of 1000 metres in 10 or 15 minuter. But if it has taken as much as 30 minuter or more to haul the bottle up from 2000 or 3000 metres, the readings obtained cannot be trustworthy, as experiments have proved that the insulation of the bottle is not sufficient to keep the temperature-readings unaltered for such a long time. It is thus seen that the temperatures cannot be very accurate, at all events from the deep strata. The readings may farthermore have been too low owing to cooling by expansion of the water and the solid parts of the water-bottle (especially the india-rubber), on hauling up from great depths. It seems, however, more probable that they have been too high, owing to deficient insulation during the long period the bottle was being hauled up, and owing to the insertion of the thermometer after the bottle had come up on deck. It may therefore be expected that the temperature of -1.23° C. at 3100 metres, at Station I ($77^{\circ} 11' N.$ Lat., $0^{\circ} 55' W.$ Long.) is somewhat too high, in spite of the considerable cooling caused by hauling the instrument up from this depth.

Much worse than the inaccuracies of the deep-sea temperatures thus caused, is, however, the fact that the water-bottle has not worked properly

¹ O. Pettersson and Hj. Östergren, Vattenprof tagna under "1900 Års Svenska Zoologiska Expedition", *Ymer*, vol. XX, Stockholm, 1901, pp. 325—329.

at Station II, the releasing propeller having obviously not functioned at the desired depths. During the first cruise of the "Michael Sars" in the same summer, 1900, there were on board several water-bottles and among them two instruments of exactly the same form as that used by Östergren, and made simultaneously by the firm L. M. Ericsson in Stockholm. The bottles were closed by a releasing propeller; but it was found that the propeller very often failed to release and close the bottle at the desired moment, especially at great depths; a fault which was afterwards remedied, and does not occur with bottles of the newer pattern. Östergren has evidently had exactly the same experience with his water-bottle of this same make (at Station II) without noticing it. His temperatures for 1000 and 2000 metres (see Section IX) are much too high¹; the temperature and salinity as given for 1000 metres indicate that the bottle has on that occasion been closed somewhere between 500 and 700 metres, where there was also a salinity similar to that of the bottom-water. The salinity obtained from 2000 metres is impossible, and indicates that the bottle has probably been closed at a depth of about 90 metres instead of 2000 metres. According to the list of observations, which Prof. Pettersson kindly sent me, another observation was also taken at 1500 metres, which, however, gave a temperature of 0.28°C. , indicating that the bottle had been closed somewhere in the intermediate warm water-stratum. The authors left out this observation in their published Table. It is consequently seen that at this Station the water-bottle has probably worked properly down to 700 metres, but below this depth no observations taken are trustworthy.

The salinities published by Pettersson and Östergren are evidently computed according to Pettersson's former method, and are consequently higher than those obtained by Knudsen's Tables. The difference is somewhat higher than might be expected. To judge from the salinities given of the cold bottom-water at both Stations, which are very uniform, the salinities are evidently about 0.10‰ too high and have therefore here

¹ According to the observations published, Östergren already found the typical bottom-water of the Norwegian Sea at 700 metres, with a temperature about -0.5°C. and a salinity about 34.93‰ , and at this depth the water-bottle has probably closed properly. But if so, it is impossible that the temperature could have been higher at 1000 and 2000 metres but the salinity evidently very nearly the same; such conditions are against physical laws, and are found nowhere in the bottom-water of the Norwegian Sea. It is of course possible that in the deepest hollows of the basin there might be a slight rise of temperature towards the bottom, owing to the underground heat of the lithosphere.

been reduced accordingly, and the densities were calculated from the values as thus obtained, which give very probable results.

During a cruise with the *Michael Sars*, under Dr. J. Hjort, in 1900, which Helland-Hansen and the writer joined as oceanographers, several Stations (*M* 16—*M* 47, Pl. V), between Iceland and Jan Mayen and east of the latter, were taken in August, 1900¹. The temperatures were determined by an insulated water-bottle of the writers construction, provided with fixed deep-sea thermometer; temperatures were also determined by some specially constructed Negretti and Zambra Reversing Thermometers divided into tenths of degrees Centigrade. The thermometer-readings have been carefully corrected, for instrumental errors, zero-correction, alterations due to pressure, etc., and may be accepted as the most accurate observations hitherto made in these regions. The water-samples were to a great extent taken in Soda Water bottles, containing 600 cubiccentimetres, and closed with patent india-rubber stoppers. The determinations of salinity were made with the Hydrometer of Total Immersion, and by Titration. The determinations, especially the former, are very accurate; but the salinities obtained by titrations, have a tendency to be somewhat too high, evidently owing to some slight evaporation through the cork-stoppers of the glass-bottles which were employed to contain the small samples (of 100 ccm.), taken for titration. It is probable that Amundsen's samples have been more trustworthy in this respect, as they were greater (150 ccm.) and were more carefully closed. His comparatively low values of the amount of Chlorine in the bottom-water (giving salinities between 34.90 and 34.92 ‰) may therefore be considered as more accurate than those of the above titrations.

The Stations of the various Expeditions have been introduced on the chart Pl. V, Fig. 1. The observations at these Stations have been used for the construction of the maps (Pl. V) showing the horizontal Distribution of *Temperature*, *Salinity*, and *Density* in the northern Norwegian Sea at 0, 50, 100, 200, 300, and 400 metres, chiefly in the months between June and August. Besides the Expeditions mentioned above, the observations of the following Expeditions have also been used for these maps:

Expedition of the *Michael Sars* in February and March, 1901 (between Norway and Bear Island), in April to July 1901 (between

¹ Cf. Helland-Hansen and Nansen, *The Physical Oceanography of the Norwegian Sea, Report on Norwegian Fishery and Marine Investigations*, vol II, No. 2. See also F. Nansen, *Some Oceanographical Results of the Expedition with the Michael Sars 1900*, *Nyt Mag. for Naturvidenskaberne*, vol. 39, Christiania, 1901, pp. 129—161.

Norway and Spitsbergen), in February 1903 (between Norway and Jan Mayen);

Expedition of Capt. C. Ryder in June, 1891, and Aug. 1892 (between Greenland, Iceland, and Jan Mayen);

Expedition of Admiral Makaroff, on board the "Yermak" in June and August, 1899 (Bear Island and Spitsbergen);

Expedition of Dr. Knipowitsch July and October, 1901 (Barents Sea, and between Norway and Bear Island);

Expedition of Dr. Breitfuss in August and October, 1902 (Barents Sea).

In order to illustrate the vertical distribution of Temperature, Salinity, and Density in the region of Amundsen's Stations 13—23, Sections IV—X (Pls. VI—XI) have been constructed.

Vertical and Horizontal Distribution of Temperature and Salinity in the Region of Amundsen's Stations 13—23.

The sections in connection with the maps (Pl. V) give a very clear picture of the vertical and horizontal distribution of temperature, salinity, and density in this northern region. The oceanographic conditions of the region of Amundsen's Stations are seen to be in several respects strikingly different from those of the surrounding regions, with the exception of the Stations 302, 303, and 304 of the Norwegian North Atlantic Expedition 1878, (see Section IV, Pl. VI) where there have evidently been much the same conditions¹.

In Amundsen's region the isotherm of -1° C. of the bottom-water (having a salinity of about 34.90—34.92 ‰) rises to within a very short distance below the water-surface, especially in the eastern central part of it — about Stations 13, 14, 15 and 16 (see especially Section IX, Pl. X, and also Sections IV and V). The reason why the isotherm rises so high especially at these Stations, is evidently to some extent because they were taken earlier in the season (in June) than the others, and the cold heavy water had not yet sunk to the depth reached later, in July.

¹ There has probably been no intermediate warm water-stratum at these Stations, the temperatures have continuously decreased downwards as at some of Amundsen's Stations, and under these circumstances Mohn's thermometers have probably given fairly trustworthy readings. The following thermometers were used at these stations: four Miller-Casella Deep-Sea (maximum and minimum) Thermometers, one Buchanan Mercury Piezometer, two Casella-Buchanan Thermometers, and one Negretti and Zambra Reversing Thermometer.

Stat. 23 (July 11 and 12) was, for instance, taken more than three weeks later than the first Station in this region, Stat. 13 (June 19).

At Stat. 14 (June 20, Table II) there was found already at 80 metres water with a temperature of -1.25°C ., a salinity of 34.87‰ , and a density of 28.07 (or very nearly the same characters as the bottom-water), and this is the place amongst Amundsen's Stations where the cold bottom-water comes nearest to the surface¹. The isotherm of -1°C . rose to about 50 metres, where there was a salinity of 34.83‰ . Station 21 is very nearly at the same spot (about 10 kilometres further west), but was taken nineteen days later (on July 8). The isotherm of -1°C . had then sunk to 150 metres (see Section IX, Pl. X), the temperature was gradually decreasing downwards and there was only a slight indication of an upper minimum at 60 metres, the temperature (-0.82°C .) being nearly the same as at 100 metres (-0.83°C .).

At Stat. 16 (Sect. IX) there was indications of an upper minimum (-1.05 to -1.11°C .) between 60 and 150 metres, but the salinity (34.88 and 34.90‰) was very nearly that of the bottom-water, and there is no distinct separation of the one layer from the other.

At Mohn's Stations 302 and 303 (June 19, 1878) the isotherm of -1°C . also rises very near the water-surface (to about 50 metres below it) and here even the isotherm of -1.2°C . seems to rise very high, to about 150 metres below the water-surface (Section IV, Pl. VI).

But outside the region of Amundsen's Stations and the above Stations of Mohn, the isotherms of -1°C . and -1.2°C . slope steeply off towards all sides, both east and west (Sects. IV and V) and south and north (Sects. VIII and IX). A section through Amundsen's southern Stations (Sect. VI) gives a very low situation to the isotherm of -1°C .; and in Sect. VII, farther south, the isotherm of -1°C . has sunk almost beyond sight.

¹ At Station 13, there was a temperature of -1.15°C . already at 25 metres, but the salinity was only 34.38‰ and the density 27.68 . This is evidently water from the Polar Current. At 50 metres there is a minimum of -1.37°C ., and 34.81‰ , with a density of 28.04 ; and here there is some approach to the nature of bottom-water. It seems as if the water at this depth was slightly heavier than the water at 100 metres, with a density of 28.03 ; but if this be not simply due to a slight inaccuracy, of about 0.01‰ , in the determination of the chlorine, it might also be due to the fact that the instruments were released by propeller after having been hauled up 3 or 4 metres, and the water samples thus have come from a stratum slightly above the one from which the temperature was taken by reversing thermometer. As there was an interval of about 17 minutes between both observations, there is also a possibility that some displacement of the water may have taken place.

Even in a section (Sect. X) through Ryders Stations (taken in the beginning of July, 1891), north of Amundsen's region, the isotherm of -1° C. and -1.2° C. lie comparatively low; whilst there is an upper minimum, between -1° and -1.5° , at about 60 and 100 metres, extending westwards into Mohn's Stations 350 and 348, where it is lying somewhat deeper and underlying a layer of much warmer water. But these Stations were taken in August, 1878; *i. e.* a month later in the season. The salinities at Ryder's minimum have evidently been very low. To judge from the very inaccurate determinations of specific gravity and salinity (by K. Rørdam) they may have been between 34.3 and 34.6 ‰ (by Knudsen's Tables), at Ryders Stations IX and X, which is much about the typical salinity of the coldest Polar water of the top layers in the North Polar Basin as well as in the East Greenland Polar Current.

The isopycnals of 28.00 and especially of 28.10 also rise to levels very near the sea-surface at Amundsen's Stations, and slope off towards the sides, especially towards north and south (see Sections VIII and IX) and towards west (Sects. IV, V, VI), but not so much towards east (see Sect. IV), where very heavy water obviously occurs in the region of Mohn's Stations 302 and 303 etc.

The maps, Pl. V, give interesting pictures of the horizontal distribution of Temperature, Salinity, and Density, in the summer, at 50, 100, 200, 300 and 400 metres. They show that in the region of Amundsen's Stations there are quite peculiar conditions, it forming, as it were, a centre of cold and heavy water.

It is necessary to distinguish between two kinds of cold water in these maps, *viz.* the *cold water of the surface layer*, between 0 and 200 metres, of the East Greenland Polar Current (and that of the Barents Sea), which at some places, *e. g.* round Jan Mayen and between Jan Mayen and Iceland, has sunk down to greater depths, — and the *cold bottom-water* of the Norwegian Sea which in the region of Amundsen's Stations rises so near to the surface that it is in contact with the cold surface water. East of Iceland and between Iceland and Jan Mayen the surface of this bottom-water rises so high that it is visible in the maps (see especially those for 300 and 400 metres). At Ryders Stations II and III, June, 1891, between Iceland and Jan Mayen, this cold bottom-water was obviously in contact also with the cold surface water.

The map for 200 metres gives a good idea of the distribution of these two kinds of cold water. In the region of Amundsen's Stations the cold bottom-water is surrounded by the isotherms of -1° C. and 0° C. The former forms a closed ring round Amundsen's eastern, and

earliest, Stations and Mohn's Stations 302 and 303. The isotherm of 0° C. obviously forms a ring outside this region as indicated in the map. It must be closed in the unknown region to the north; for in the North Polar Basin, in the western part of the Fram's route (Stats. 19—26)¹ there were found temperatures above zero at 200 metres; and the cold surface water was separated from the cold bottom-water by a layer of water 600 metres thick, with temperatures above zero. At Kolthoff's Station -I (*F* I) the temperature was 1.02° C. at 200 metres; and at Mohn's Stat. 351 a temperature of 0.1° C. was observed at 183 metres (100 fathoms), but, as before mentioned, Mohn's temperatures, are liable to be too low for intermediate warmer layers. Along the Greenland coast there is another region of water with temperatures below 0° C. at 200 metres; but this is water with low salinity, from the cold surface layer of the Polar Current, pressed down against the coast on the right hand side of the Polar Current (see Sections IV—VII). Round Jan Mayen there is similar cold surface water with low salinity at 200 metres, which has been pressed down round the island. Section VII (Pl. IX) shows clearly that there cannot be any communication between this cold water and the cold bottom-water of the same depth at Amundsen's Stations to the north; for the cold surface-water at 200 metres near Jan Mayen (Ap. II and M. S. 29) is separated from the cold bottom-water by several hundred metres of warmer water (see Sect. VII). To the north of Iceland there are similar conditions; the polar current is there blocked by the land, and its cold surface waters are pressed down below 200 metres, at some places.

The salinity at 200 metres is fairly uniform in the greater part of the region, generally, between 34.90 and 34.95 ‰. But it is very characteristic that the salinity is on the whole lowest near the centre of the cold region, and there is a small area where it is even 34.88 and 34.89 ‰. In this central region the cooling has consequently been sufficiently great during the winter to make this water, with a somewhat lower salinity, so heavy that it can sink down from above.

The map shows that at 200 metres, the densities increase towards the central part of the region, and approach 28.10. The isopycnal of 28.10 forms a closed curve, whose area does not coincide with that of the isotherm of -1° C., but is somewhat to the west of it. The isopycnal of 28.00 passes outside the region on both sides, east and west.

¹ F. Nansen, *Oceanography of N. P. Basin*, p. 306.

In the maps for 300 and 400 metres, the isotherms of -1° C. and 0° C. have very similar contours in the region of Amundsen's Stations, as have also the isopycnals of 28.10 and 28.00; but the area of the cold heavy water increases with the depth so that the rings formed by the curves become wider. All traces of the cold surface-water have almost disappeared in these maps — except perhaps, to the north of Iceland; — whilst there is, especially at 400 metres, an axis of cold bottom-water extending northwards, towards Jan Mayen, from the sea east of Iceland.

In the maps for 50 and 100 metres, the cold Polar water of the upper layers, with temperature below 0° C. and -1° C. and salinity below 34.9 and 34.8 ‰, has a wide distribution east of the Greenland coast and north of Iceland. But in the region of Amundsen's Stations the conditions are very peculiar, and there is an intimate connection between the cold water near the surface and the cold bottom-water. The isotherm of -1° C. forms a closed curve near Amundsen's region, in the map for 100 metres, and so does the isotherm of 0° C. almost. The isotherm of -1° C. also encloses a special area in this region at 50 metres, whilst the isohalines of 34.9 and 34.8 ‰ form peculiar tongues extending westward. The isopycnal of 28.00 forms closed curves or rings in both maps for 50 and 100 metres, but it is much wider in the latter.

It is clear that there here is very nearly the centre of the region where the homogeneous bottom-water of the Norwegian Sea chiefly arises, and it is also clear that this bottom-water must be formed by cooling at the sea-surface during the winter, just as in the case of the bottom-water of the Barents Sea, described in the previous chapter.

By examining the characteristic features of the vertical distribution of Temperature, Salinity, and Density in and under the waters of the North Polar Current, in the North Polar Basin and along the East coast of Greenland, it will easily be seen that the bottom-water of the Norwegian Sea cannot be water from this current, as was generally assumed.

The Vertical Distribution of Temperature and Salinity in the East Greenland Polar Current and Underlying Waters.

West of Amundsen's Stations is the region of the East Greenland Polar Current, with very typical vertical distribution of temperature and salinity, of much the same character as found by the writer in the North Polar Basin. Near the water-surface there is a layer of Polar water,

with low temperature and salinity¹, and a temperature-minimum of between -1.5 and -1.8° C., at between 40 and 60 metres.

In the eastern part of the Polar Current, at Amdrup's Stat. III (*Ap.* III) and Ryders Stat. XII (*R.* XII) the minimum is at 30–50 metres. The salinity of this minimum varies between 34.3 and 34.6 ‰. In the western part of the current, near the Greenland coast (*N.* IX), the salinity of the minimum is much lower, *viz.* 33.2–33.7 ‰. The density of this minimum is about 27.6–27.8 (*N.* VII and *Ap.* III). Near the Greenland coast it is much lower, 26.7–27.1 (*N.* IX).

Underneath this cold Polar water coming from the North Polar Basin, is a warm layer of Atlantic water with temperatures above zero, and salinities above 34.9 ‰. The density is about 28.04–28.07. Underneath this warm layer is colder water again, the temperature of which gradually sinks below zero, and decreases downwards to below -1° C., at depths greater than 1000 metres (see Sections IV–VI, VIII, X). The salinity of this cold bottom water is very uniform, as a rule between 34.90 and 34.92 ‰ (computed by Knudsen's Tables from the amount of Chlorine), and its density increases gradually downwards, from 28.07 towards 28.11 or 28.12.

These conditions, typical of the North Polar Current, are also found south of Amundsen's Stations, at Kolthoff-Östergren's Station II (*F* II), and at Amdrup's Stat. II (*Ap.* II) west of Jan Mayen (see Sect. VII). Even east of Jan Mayen, at "Michael Sars's" Station 29 (*MS* 29) there are indication of the same polar conditions, except that the upper temperature minimum was not so low (-0.66° C.), and was depressed somewhat deeper, to about 80–100 metres, with salinities about 34.7 ‰.

In the sea between Jan Mayen and Iceland there is also to a great extent the same vertical distribution of temperature and salinity as in the East Greenland Polar Current farther north, which is proved by the Stations 18 und 19 (*MS* 18, *MS* 19, Sect. IX) of the Michael Sars, and several Stations of the Ingolf Expedition.

Ryders Station II (June 22, 1891, *R* II, Pl. V), in $68^{\circ} 24'$ N. Lat. and $14^{\circ} 4'$ W. Long., is a somewhat strange exception. Here the vertical distribution of temperature is very different from that shown by all other series of temperatures in this region, as is seen by the following

¹ The writer has before pointed out that it is a mistake to believe that this layer of polar water, with low salinity, is formed by the melting of the ice, as Prof. O. Pettersson and other authors seem to assume. The water is an outflow of the Polar water covering the North Polar Basin to a depth of about 200 metres, and this water has its low salinity by being diluted with fresh-water, chiefly from the Siberian rivers.

table, where Stat 18 of the "Michael Sars", and Stat. 125 of the Ingolf Expedition, one on each side of Ryders Station, are given for comparison. The salinities are computed by means of Knudsen's Tables. (For Ryder's salinities have been used the determinations with hydrometer, and at some depths the mean between these values and the values of $S \frac{15^{\circ} \text{C.}}{15^{\circ} \text{C.}}$ found by Rørdam with the pycnometer). Ryders Station was taken several miles inside the edge of the drifting ice-masses. While the upper temperature minimum is at the usual depth of about 50 metres at the "Ingolf's" Stat. 125, and at the "Michael Sars's" Stat. 18, there is a remarkable minimum of -2.1°C. in about 180 metres at Ryder's Station. The temperature of -2.1°C. is, however, evidently erroneous, as it is below the freezing-point of the water (which is about -1.9°C. if

Depth in Metres	Ingolf 125 July 29, 1896 68° 8' N. 16° 2' W.	Ryder II June 22, 1891 68° 24' N. 15° 4' W.	M. Sars 18 Aug. 6, 1900 69° 9' N. 12° 0' W.	Ryder III June 25, 1891 69° 51' N. 11° 18' W.	M. Sars 19 Aug. 7, 1900 70° 35' N. 11° 10' W.	Ingolf 117 July 23, 1896 69° 13' N. 8° 23' W.
0	2.1° C. 33.2 ‰	-1.0° C. 33.5 ‰	5.7° C. 34.2 ‰	-0.2° C. 33.7 ‰	4.5° C.	4.1° C. 33.82 ‰
18		-1.0° C. 33.7 ‰	5.5° C. 34.27 ‰	-0.5° C.	4.3° C. 34.27 ‰	
55	-1.2° C. 34.5 ‰	-1.5° C.	-1.4° C. 34.6 ‰	-1.6° C. 33.8 ‰	-1.4° C. 34.6 ‰	-0.7° C. 34.72 ‰
94	0.2° C. 34.7 ‰	-1.9° C.	-1.0° C. 34.7 ‰	-1.8° C. 34.04 ‰	-0.5° C. 34.7 ‰	-0.9° C. [33.95 ‰]?
188	0.8° C. [34.5 ‰]?	-2.1° C.? 34.9 ‰?	0.6° C. 34.9 ‰	-1.1° C.	0.3° C. 34.89 ‰	-0.7° C. 34.99 ‰?
290		-1.8° C.	0.2° C. 34.94 ‰	-0.2° C. 34.34 ‰?	0.2° C. 34.93 ‰	
370	0.4° C. 34.94 ‰	-0.1° C. 34.95 ‰		-0.4° C. 34.9 ‰	0.0° C. 34.93 ‰	0.0° C. 34.96 ‰
560		-0.3° C.	0.4° C.? 34.93 ‰	-0.7° C.	-0.4° C. 34.93 ‰	
750	-0.3° C. 34.90 ‰	-0.7° C. 34.9 ‰		-0.7° C.		-0.6° C. 35.03 ‰?
1130	-0.4° C. 34.90 ‰	-0.9° C.	-0.8° C. 34.93 ‰	-0.9° C.		-0.9° C. 35.05 ‰?
1370	-0.8° C. 34.90 ‰	-0.9° C. 34.9 ‰	-0.9° C. 34.92 ‰	-1.0° C. 34.9 ‰	-0.88° C.	

the salinity be 34.9 ‰). This may indicate that Ryder's temperatures are on the whole somewhat too low (about 0.02°C.). If it be assumed that the temperature has been near the freezing-point and that the salinity of about 34.90 ‰ be correct, the density of the water was about 28.12. This is rather heavy water; and the salinity may probably have been lower (the determination with the hydrometer gave 34.88 ‰).

The only way in which these conditions can be explained, if the observations be fairly correct, is by supposing that during the previous winter or spring there has been a vertical circulation in this region, reaching down to 200 or 300 metres; and if this vertical circulation could break through the underlying warmer water with a higher salinity, the possibility of bottom-water also being formed occasionally in this region is not excluded.

Ryders Station III (*R* II, Pl. V) shows also some resemblance to his Stat. II: the temperature-minimum lies comparatively deep (at 94 metres) and water with temperatures below -1° C. reaches down below 180 metres from the surface.

At Stat. 117 of the Ingolf Expedition (July 23, 1896, *I* 117, Pl. V) the cold surface layer has been very deep (-0.7° C. was observed at 188 metres) and the underlying warmer layer has been comparatively thin (0.0° C. was observed at 377 metres); but the values of the salinities are evidently too high, as they give much too high densities¹.

North of Amundsen's Stations, at Mohn's Stat. 350 (*M* 350) and Kolthoff-Östergren's Stat. I. (*F* I), there are also indications of a vertical distribution similar to that of the North Polar Current and underlying water-strata (see Sect. IX, Pl. X).

In the North Polar Basin, along the track of the "Fram", the conditions were very much the same as in the case of the East Greenland Polar Current. The water of the upper temperature-minimum at 50 or 60 metres²

¹ The Station 217 of the Norwegian North Atlantic Expedition (July 27, 1877) in $71^{\circ} 0'$ N. Lat. and $5^{\circ} 9'$ W. Long. seems to form a most remarkable exception, if the temperatures given can be trusted; but as they were all taken with the Miller-Cassella Thermometers this may be doubtful. They give a minimum of -1.8° C. at 55 and 94 metres (the minimum thermometers may be expected to have given this temperature correctly), and below this depth the temperature nowhere rose above -1.1° C. If this really be correct, it seems as if the region with bottom-water near the surface, has that summer extended so far south as towards this Station. That this may actually have been the case, might also be indicated at the nearest Stations 218 and 219, where temperatures of -0.9° C. and -1.1° C. are met with at 55 or even 37 metres. It may, however, be that this has only been a temperature-minimum of an upper layer of Polar water, whilst the Minimum and Maximum Thermometers have not been able to indicate the higher temperatures of the underlying, warmer water, as the sea-surface was covered by a warm water-layer of about 4 or 5° C.

² In writing 'The Oceanography of the North Polar Basin' it was assumed that the water of this temperature-minimum "must originate from other parts of the North Polar Basin, where the water near the surface has a similar salinity" (*cf. op. cit.*, p. 323). It did not seem to appear probable that there was sufficient ice at depths between 50 and 70, or 80 metres, to cool the whole water stratum down to near its freezing point, and the distance between the great hummocks, reaching so deep, was thought to be too great to produce such a general effect. But, upon considering the question more closely, it must be concluded that an appreciable cooling of the water may be thus

has salinities below 33.8 ‰ (33.3–33.8 ‰) and densities (σ_t) below 27.20¹, and the cold top layer of Polar water rests on a thick, intermediate layer of warmer water with much higher salinity.

It is thus seen that nowhere under the North Polar Current, in regions hitherto known, can the cold and heavy bottom-water be cooled down to its low temperature by direct contact with the cold but much lighter top-layer, from which it is everywhere separated by an intermediate warmer layer. It is obvious, that the bottom-water of the Norwegian Sea cannot originate directly from the East Greenland Polar Current².

produced down to the greatest depths of the ice, which may possibly be 60 or 70 metres or perhaps even more; and Prof. O. Pettersson's suggestion that this temperature-minimum may be due to contact between the sea-water and the ice (see *Geographical Journal*, London, vol. XXIV, 1904, pp. 318, 320, and 322), therefore seems very probably true, although according to the direct observations made (*e. g.* measurements of the height of the same hommock during a long period of many months) Pettersson is not right when he assumes that an appreciable melting of the ice may be produced by this contact in the North Polar Basin. During the frequent ice-pressures the ice-floes are broken and piled up into ridges and hummocks and during the winter and spring ice-blocks with very low temperatures, of -20.0 or even -30.0°C . (*vide* measurements, the *Norw. North Polar Exp. 1893–1896*, *Scient. Results*, vol. VI, pp. 544–557), are then pressed down to great depths. This cold ice will have a great cooling effect upon the water with which it comes into contact, because a considerable quantity of heat is required to raise its temperature to the freezing point (-1.84°C .) of sea-water with a salinity of about 33.7 ‰ (not 35.0 ‰ as stated by Pettersson, *loc. cit.* p. 318), and to liquefy the frozen brine in the ice. Much ice will thus be formed round the cold ice-blocks, and the blocks of one hummock may be thus united more or less into one solid mass before an equilibrium is attained between the temperature of the ice and that of the surrounding water which will be cooled down to its freezing point of about $-1.84^{\circ}/_{100}$, at the same time as its salinity is slightly raised. Contact between the ice and the sea-water alone will cool the latter, but it is clear that after the water-stratum has been thus cooled down to near its freezing-point no appreciable melting of ice can be produced, because there is such and extremely slow vertical circulation owing to the rapid increase of salinity and density downwards. The quantity of heat given off by a water-stratum 10 metres thick which is cooled 0.1°C ., is hardly sufficient to melt 1.5 centimetre of ice.

¹ Cf. Nansen, *op. cit.* pp. 246–255, 306, and Pl. XVI.

² Professor Otto Pettersson has propounded the hypothesis (see *Geographical Journal*, vol. XXIV, London, 1904, p. 285) that by the melting of Polar Ice in the western and north-western parts of the Norwegian Sea, the Atlantic water should be cooled and sink towards the bottom. According to what has been pointed out above, this is not possible to any appreciable extent, as long as the Polar ice floats in the water of the Polar Current; on account of its low salinity, this water cannot sink, even if it could be cooled down by the melting of ice to a lower temperature than it had beforehand. The real Polar ice very seldom comes outside the boundaries of the water of the Polar Current in the Norwegian or East Greenland Sea. The melting of the Polar Ice, cannot therefore have any appreciable direct effect upon the cooling of the underlying Atlantic water, from which it is always protected by an layer of cold water with much lower salinity.

To avoid misunderstanding, it may be mentioned here that there are also in the Norwegian Sea great masses of ice, which are formed in that same sea during the winter, and which occur even outside the region of the Polar Current. This ice, which

It is also clear that water like the bottom-water cannot arise by an intermixture of cold Polar with warmer Atlantic water, because the former, having temperatures below -1°C. , has too low salinities of between 34.3 and 34.7 ‰. The water with a temperature of about -1°C. near the under-side of the East Greenland Polar Current has a salinity of about 34.7 ‰. Below this water-stratum both temperature and salinity rise downwards, whilst above it they both decrease. Water with a temperature of about -1.4°C. and -1.5°C. has salinities below 34.6 and 34.5 ‰. If Atlantic water be intermixed with this water to obtain a bottom-water with a salinity about 34.9 ‰, so much of the former would have to be added, that the temperature could not possibly become very low, even assuming that the Atlantic water had been much cooled beforehand.

In the regions where the bottom-water arises, there must be expected very nearly the temperature and salinity of this water from the bottom upwards and towards the depth at which it is formed; it cannot possibly be separated from the temperature minimum of the top-layer by any intermediate warmer layer. The cooling can only come from the sea surface, and the water must, as a rule, be gradually heated after it has sunk to greater depths.

Before discussing the necessary conditions for the formation of the cold bottom-water, the conditions that may be required for the existence of an intermediate warmer water-stratum, will be considered.

The Intermediate Warmer Water-Stratum underlying the East Greenland Polar Current.

It is clear that, where the underlying warmer water is not protected by an overlying water-stratum with a much lower salinity, it cannot exist for any length of time, for the cooling during the winter would make the top layer heavier than the underlying warmer water. An active vertical circulation would be thus produced, with the result that the whole bulk of water to considerable depths, would be cooled down. Where, however, the underlying warm water is protected by an overlying lighter stratum of cold Polar water, it cannot be cooled down during the winter, because the vertical circulation, caused by radiation of heat

is the ice chiefly met with by the sealers in spring, melts in regions where it may come into more direct contact with Atlantic water; but as the ice is originally formed inside the same sea-basin, the final direct effect upon the temperature of the sea, by its formation and melting will be *nil*. Indirectly it will, however, reduce the cooling of the sea, by protecting the upper layers against radiation during winter.

from the surface, will not be able to reach very deep, and break through the upper water-strata, where the salinities and densities increase too rapidly downwards. The writer found that in the North Polar Basin the vertical circulation during winter, did not reach much more than 30 metres below the water-surface. Besides the water of the upper temperature-minimum is near its freezing point and cannot become much heavier by cooling. There cannot, therefore, be any considerable vertical circulation at any time of the year. The underlying warm water-stratum can thus be cooled only by conduction of heat, which is extremely slow in water, and by intermixture with the colder overlying layers, which is also slow where the densities so rapidly decrease upwards, and where the surface is covered by ice, so that the wind cannot stir the water much.

The intermediate warm layer may thus exist for a very long time, without being much cooled, and it may, therefore, be expected everywhere under the polar current, because the density of this warmer water is between that of the light Polar water, and that of the bottom-water; it will thus easily find its way in between these two waters¹.

At most of Amundsen's stations east of Greenland there is hardly any similarity to the polar conditions. At some of the western stations, (especially Stats. 17, see also Stats. 18, 19, 23), there are indications of an upper temperature-minimum at about 40 or 50 metres with an underlying, somewhat warmer layer; but the salinities are on the whole so high that an active vertical circulation may be produced by cooling during the winter. If, for instance, at Stat. 17, the water at 50 metres be slightly cooled, it will become heavier than the underlying warmer water at 60 metres.

The *temperature-maximum* at these stations, is at about 60 to 100 metres below the water-surface². Farther west, under the Polar Current, this intermediate warmer layer increases much in thickness towards the Greenland coast, while its temperature rises; — and the further west the deeper its upper boundary. The isopycnals also slope fairly steeply towards the Greenland coast (see Sections V and VI). This very characteristic feature indicates that the overlying cold Polar water-layer as well as the underlying warmer layer is in movement southwards along

¹ It is, for instance, noteworthy that in Section IV—VI, the underlying warmer water with temperature above zero, has very nearly the same extension eastward as the overlying cold water with temperature below -1°C .

² At Nathorst's Station VI (N VI) Åkerblom observed a maximum of 0.19°C . at 100 metres (see Section VI, Pl. VIII).

the Greenland coast, with velocities, which are greaterst near the surface, and decreasing downwards. By the deflection caused by the Earth's rotation, both the cold and the warm water-layers of the current, being lighter than the underlying bottom-water, which has a slower motion, are pressed against the coast, and are there depressed, on to the right hand side of the current, as is always the case, where a current moves along a coast on its right hand side (*cf.* for instance, the Gulf Stream along the Norwegian coast and along that of Spitsbergen).

Prof. Pettersson has propounded the theory, that this warm intermediate water should come directly from the east or southeast, by "an under-current of Atlantic water, which at about 72° N. Lat, branches off from the main body of such water in the Norwegian Sea, and north of Jan Mayen flows in a north-westerly direction towards the coast of Greenland", and as evidence of the existence of this current he mentions the temperature series of Östergren taken at Kolthoff's Station II (*F* II)¹. What has been said above makes this theory appear highly improbable. Section VII (Pl. IX) also further demonstrates its improbability. The warm water underlying the cold water at Stations *N* IX and *N* VII, cannot move northwards, for if so, it would necessarily have quite a different position². It cannot, therefore, come from the south or south-east. It seems then to be much more probable that it may come from the region of the warm intermediate water-layer at Östergren's northern Station (*F* I, see Sect. IX, and the maps for 100—400 metres, Pl. V). At any rate, the warm water underlying the East Greenland Polar Current must come from the Atlantic Current (Gulf Stream) running north, along the eastern margin of the deep basin of the Northern Norwegian Sea; and somewhere to the north of Ryder's, Nathorst's, Amdrup's, and Amundsen's Stations it must come from the east by a partially cyclonic movement. It seems also possible that some part of this warmer water may come along with the overlying cold current from the North Polar Basin. At Station 23 (July 1895) of the Fram-Expedition, in $84^{\circ} 32'$ N. Lat., $73^{\circ} 55'$ E. Long., the

¹ Otto Pettersson, On the Influence at Ice-Melting upon Oceanic Circulation, *Geographical Journal*, vol. XXIV, London, 1904, p. 309.

² It might be objected that the observations at Amdrup's Station (*Ap.* III) are not from the same year as those of Åkerblom (at Nathorst's Stations *N* VII, *N* IX). But Ryder's Stations (*R* XII, *R* XIII, and *R* XIV) give exactly the same picture, which indicates that this is a characteristic feature of the current.

intermediate warm layer had a temperature about 1.18°C . at 300 and 350 metres¹.

It was already mentioned above that wherever the sea is covered with a toplayer of comparatively light Polar water, with low temperature and low salinity, there must be also expected an intermediate layer of warmer water with higher salinity between the light top layer and the heavy bottom-water; and simply because this warmer water has a density between that of the top layer and that of the bottom-water. From the adjacent warmer parts of the ocean it will therefore everywhere find its way in between the two colder waters. This characteristic feature is therefore found in the North Polar Basin, in the northern parts of the Barents Sea, in the East Greenland Polar Current, in the Baffin Bay, and also in the Antarctic Sea.

At most of Amundsen's Stations it is not found, because there is no top-layer of the typical light cold polar water, and because the sinking of the heavy surface water has given no room for this warmer intermediate water; but it is possible that it might appear, to some extent, later in the season when the heavy water has sunk to lower levels.

Melting of Ice due to underlying Warmer Water.

Prof. Otto Pettersson and Hj. Östergren believe that it is the assumed warm undercurrent North of Jan Mayen which keeps the way open to the east coast of Greenland almost every summer², and Pettersson also believes that these currents underlying the cold water, are on the whole of much importance in the melting of the ice of the Polar seas. Precisely how the authors think that this undercurrent could manage to keep the way open, does not, however, seem to be quite clear; is it by altering the direction of the surface current, or by melting the ice on the surface? The latter is impossible, simply because the warm undercurrent is separated from the overlying ice by a layer of

¹ Prof. Pettersson mentions as evidence going to show that the underlying warm water of the East Greenland Polar Current cannot come from the north, that Dr. Åkerblom found it to contain a very high percentage of oxygen (32.94%). He believes that, if this under current had made "the grand circuit along Spitsbergen etc." its contents of oxygen ought to have been far more reduced. He seems to forget, however, that under the Polar Current covered by ice there is very little animal life to reduce the oxygen, and it must therefore be expected that even in the North Polar Basin the underlying warm water will always have a comparatively high percentage of oxygen.

² *Op. cit.* *Ymer*, vol. XX, 1900, Stockholm, p. 327.

cold Polar water which has a temperature-minimum at about 60 metres. No melting of the ice near the surface, worth mentioning, can be caused by conduction of heat through the water from the underlying warmer water; for in this manner, it would require about one year to melt a centimetre of ice, provided that the rise of temperature be as much as 2°C . per 100 metres from the under-surface of the ice downwards.

The melting thus caused is consequently a negligible quantity. The heating of the overlying cold strata by the warmer under-current is to a much greater extent caused by the intermixture between the two waters. But even in this manner only an extremely slow heating can be produced, because the overlying layers are so much lighter, that the intermixture between them will proceed extremely slowly¹. It is, therefore, found that the temperature as well as the salinity of the cold surface layers of Polar water very slowly rise on the way southwards along the Greenland coast. And furthermore, it is found that in the East Greenland Polar Current there is, at least in the summer, a temperature-minimum at 60 to 80 metres², and this minimum would naturally soon be washed away if such an active intermixture occurred as would be necessary to cause any appreciable melting of ice near the surface, by heating from below³.

¹ As the sea-surface is covered by ice, the wind will have little opportunity to stir the waters, and where the density rapidly increases downwards, the lighter layers will glide over the heavier ones with very little friction, and without causing vertical movements of any great extent.

² At Amdrup's Station III (*Ap*. III), near the eastern margin of the East Greenland Polar Current, the minimum (-1.45°C .) lies somewhat higher, at about 30 metres, and there may be a more appreciable heating from below, though even here it cannot be considerable; for at 40 metres there is -1.4°C . and at 60 metres -1.05°C . The temperature of -0.05°C ., and salinity of 33.10 ‰ at 50 metres is of course erroneous, the water-bottle has obviously been closed near the water-surface.

At Ryder's Station XII (*R* XII) there may also be a slight heating from below. At these Stations it is therefore possible that some slight melting might be caused by heating from the underlying warmer water.

³ Prof. Otto Pettersson might perhaps object that this minimum is due to melting of the lower part of the great hummocks reaching down to depths of 50 and 60 metres or more. But howsoever this may be, it is at least certain that there is much more ice nearer the surface and consequently much more melting is going on there. But in spite of this the temperature rises towards the surface during the summer, by being heated from above, to much above its freezing point; and it is, therefore, clear that the melting of ice in this water is chiefly, or almost exclusively, due to the direct heat of the sun, which melts the ice on the surface, and heats the water in which it floats. It is of course impossible that water overlying a temperature-minimum can be heated from strata underlying this minimum, for as long as this stratum with a minimum temperature exists, it must naturally have a cooling effect upon the overlying strata.

It ought also to be remembered, that if the heat required to melt, for instance, 1 metre of ice be taken from the water, it would cool down by 1° C. the underlying water-layers to a depth of 79 metres; but this is not possible, because on the one hand the underlying layers of Polar water are too cold beforehand, and on the other hand no vertical circulation, necessary to produce such a cooling, can occur in these water-strata, where the density too rapidly decreases on rising towards the surface.

Let it, however, be assumed that the vertical circulation in the East Greenland Polar Current might reach down to 79 metres (which it however does not, as is proved by the vertical series of temperatures and salinities). Let it also be supposed that the mean temperature of this water-layer, 79 metres thick, be -1.5° C., and its mean salinity be 34.0‰ (which is too high). The freezing-point of water with this salinity is about 1.85° C. It is consequently seen that if this bulk of water be cooled down to freezing-point from -1.5° C., the quantity of heat thus consumed will melt a continuous layer of ice 0.35 metres thick. But in the summer, while the ice-melting is going on, the temperature in the East Greenland Polar Current rapidly rises towards the surface from the temperature-minimum at about 50 or 60 metres. And already by the beginning of July, the surface temperature has risen considerably, to 0.9° C. (at Nathorst's Stat. *N* VII), to -0.1° C. (at Ryders Stat. *R* XII), and to -0.2° C. (at Amdrup's Stat. *A* III), whilst in the winter the water was cooled down to its freezing-point, about -1.7° C. This rise of temperature is due to the heat-wave (caused by direct radiation from the sun) penetrating downwards from above, and it shows that the melting of the ice is not able to prevent the heating of the water from above, and consequently, as long as the ice floats in the diluted cold water-layers of the Polar Current, its melting during the summer, both on its upper surface and on the under-side of the floes, must be due chiefly to this heat from above (which may either melt the ice directly, or heat the surface water in which the ice is floating), and not to heat coming from the intermediate layers of warmer water underlying the Polar Current, and against which it is well protected by the cold waters of the latter¹.

¹ It ought also to be remembered that the melting point of the Polar ice is much above the temperature of this polar water, which has a layer with a temperature-minimum of -1.4 to -1.9° C. The many observations made of the temperature in the ice down to depths of 1.6 metre, during the expedition across the North Polar Basin (see *Norw. N. Polar Exp. 1893-1896, Scientific Results*, vol. VI, pp. 545-557) show that during the polar summer, in July and August, the temperature in the ice rises to about -0.4° C. even at 1.6 metre below its surface, and this temperature is evidently near

Direct measurements of the thickness and growth of the ice, continued during the whole drift of the Fram, prove that in the North Polar Basin it is only during the late part of the summer that there might be a slight melting on the under-side of the Polar ice-floes, and this melting is due to the heat-wave from above, penetrating down through the ice, and also into the water between the ice-floes. When the top-layer of nearly fresh water, formed by the melting of snow and ice, on the upper surface of the floes, has grown so thick that it reaches down below their under-side, new ice may be formed under the latter in spite of the heat-wave; the nearly fresh water is cooled down to its freezing point and transformed into ice by contact with the underlying cold sea-water of temperatures below -1°C .

During the winter there is no appreciable melting of ice, either in the North Polar Basin, or in the East Greenland Polar Current; but much ice is formed, and the upper strata of the sea are cooled down to freezing point by radiation from the sea-surface.

Ice floating in the sea outside the boundaries of the Polar Current — *e. g.* between Iceland and Jan Mayen, and between the latter and Spitsbergen — may, however, be melted chiefly by heat from the underlying water. But this ice is comparatively thin, and is not "Polar" ice from the North Polar Basin. It is formed during winter and spring (even as late as April) in the same sea, where it melts during summer. The writer had a good opportunity of studying the formation and melting of this ice during a cruise in the northern seas in March, April, and May 1882. Ice-masses of this kind may, to a great extent, be carried eastwards into regions where they come in more direct contact with the underlying warmer water-strata, and the melting of the ice will then be chiefly due to the heat of this warmer water. On April 9, 1882, for instance, the writer found the boundary of this "western" ice as far east as $13^{\circ} 30' \text{ E. Long.}$, in $74^{\circ} 2' \text{ N. Lat.}$; which is in the region of the warm Atlantic Current west of Bear Island. The appearance of such ice indicates at once that it is melting chiefly at its under-side. On April 10, 1882, (in $73^{\circ} 14' \text{ N. Lat.}$ and $13^{\circ} 24' \text{ E. Long.}$) it was 1.9°C . on the sea-surface, amongst scattered belts of melting ice, and 2.3°C . at about 40 metres

its melting-point. If such ice, with a melting-point about -0.4°C ., floats in water which has, for instance, a salinity of about 32.5‰ and a temperature of about -1°C ., the ice will melt until it has cooled down the water to its freezing-point, which is -1.77°C . (*cf.* M. Knudsen, *Publication de Circonstance*, Copenhagen 1903, No. 5, p. 13), but the melting will be very slow, and slower than if the ice had a melting point as low as the freezing point of the water in which it floats.

below the surface. On the same afternoon even 4.5°C . was observed on the surface, between belts of scattered ice. It was frequently found in this region that the surface-temperature was 1°C ., or 1.5°C ., or even 2°C . only short distances, less than a mile, from the edge of the pack-ice, whilst amongst the floes the temperature was near or below zero, and where there was much ice even as low as -0.6°C . On many great lanes between the floes there was, however, new ice (the so-called "bay-ice" of the sealers), and then the surface temperature of the water might be about -1.4 or -1.6°C ., indicating that the salinity of the surface-water was between 27.0 and 29.0 ‰. The temperature of the air was at this time between -5°C . and -13°C . The explanation of the low surface temperatures and new ice is, that, by the melting of the ice-masses, a thin surface-layer of water with a reduced salinity is formed. This layer, having a much lower salinity than the underlying water, cannot sink by cooling; it may thus be cooled down to freezing point by radiation of heat from the surface, and new ice may be formed.

It is clear that in regions where the conditions are as above, the ice-melting process may contribute much to the cooling of the underlying sea-water; but it has of course to be remembered that these ice-masses were also formed in the western and north-western parts of the same sea, and during the process of formation an equal amount of heat was disengaged. The formation and melting of this ice will thus far have no effect upon the average temperature of this sea basin¹.

The above considerations show, that the effect which the underlying, intermediate, warmer water-layers may have upon the formation or melting of ice on the surface, must be an insignificant and negligible quantity for all practical purposes wherever polar conditions prevail, *i. e.* wherever the sea is covered by a surface layer, 100 or 200 metres thick, of less saline water, and temperatures below zero or even below -1°C .²

¹ In a somewhat different way it will, however, have an effect, for though the formation of ice covered by snow during the winter will make the temperature of the air lower, it will also much reduce the vertical circulation of the underlying sea-water, which can then only be cooled by conduction of heat through the overlying ice and snow. The formation of ice will thus reduce the cooling of the sea, which is the opposite effect of that attributed to it by Prof. Pettersson.

² Pettersson's assertion that ice can only exist in a shallow sea, and over the continental shelves, is directly contradictory to facts. There may be mentioned the deep North Polar Basin, where the enormous masses of polar ice are formed. But we need not go so far, the northern part of the Norwegian Sea itself is a good example. In the deep sea between Jan Mayen and Spitsbergen very great masses of ice are formed during the winter and spring, as mentioned above.

*The "Opening" in the Ice towards the East Greenland Coast
in the Region north of Jan Mayen.*

Against Pettersson's and Östergren's theory must be cited the fact that in summer this opening generally occurs much north of the region where they believe that their warm under-current occurs. As a rule it is between 74° and 76° that it is most easy to reach the Greenland coast, and this is just in Amundsen's region, where there is no such warm intermediate water-layer.

It is also towards this region that the sealers steer their course every winter, in March, in order to catch young seals (*Phoca Groenlandica*). Great numbers of seal gather on the ice in the region north or north-east of Jan Mayen in order to bring forth their youngs at the end of March and beginning of April, and here they used to be slaughtered by Scotch and Norwegian sealers. The idea of the latter is that the seals always seek their breeding place in the central part of the great tongue of ice ("is-odden") which according to their experience generally extends south-eastwards or eastwards in the sea north of Jan Mayen. The situation of this tongue of ice varies much from one year to another; but on the north side of this tongue there is always, they say, a deep broad bay or bight in the ice, which they call the "bay-ice bight" ("Bay-is Bugta"). The situation of this bay varies much with that of the "tongue of ice", but its latitude may frequently be about 73 , 74 , or 75° N. Across it the shoals of seal coming from the north have to swim on their way to their breeding place. The sealers therefore used to sail into this "bay" in order to meat the seals, and follow them into the "tongue", and thus find the place where they gathered on the ice to breed. The sealers said that this bay was remarkable by having very cold water, and they called it the "bay-ice bight" because so much "bay-ice", (*i. e.* new, thin ice, which when there is a little swell, is broken up into small round discs, and is called "pancake-ice") is formed there in March and April.

This "bay-ice bight" is probably just part of the region where the bottom-water of the Norwegian Sea is formed. Here the comparatively saline sea-surface is open during a greater part of the winter; there is a considerable cooling of the water by radiation of heat directly from the sea-surface, without any intervening layer of ice, the formation of which is more or less prevented by a very active vertical circulation of the sea, penetrating to considerable depths.

The charts for 50, 100, 200, 300, and 400 metres (Pl. V) demonstrate clearly that there are special conditions in this region.

The reason why the tongue of ice, extending eastwards, is formed to the south of this region, is no doubt difficult to decide so long as no fuller investigations have been made. It may be caused by the condition of the atmosphere and the winds; the great variations from one year to another may seem to indicate that the winds are of much importance in this respect. But the following consideration may also perhaps be worthy of notice. In the region where the bottom-water is formed on the surface, there is a maximum of density, approaching $28\cdot10$ or $28\cdot12$ on the surface. The lighter surface-water of surrounding regions, especially the much lighter polar water to the west, whose density is not much increased by cooling, since it is protected by the overlying ice, will have an increased tendency to flow in this direction. But, owing to the Earth's rotation, it will be deflected towards the right, and there may thus be a tendency towards a cyclonic movement round this maximum of density, by which movement the ice would be carried southeast- or eastwards south of it.

In the atmosphere there may also be a tendency towards a similar cyclonic movement, for there will be a tendency towards a barometric minimum over this cold but more or less open sea where the air is heated by contact with the water-surface, whilst it will be much colder over the adjacent fields of snow-covered ice.

Why the seals especially choose this tongue of ice for their breeding place, is a difficult question. It may be mentioned that this seal is a very social animal, generally found in great shoals; it will naturally choose for its breeding place ice-masses, where the hundreds of thousands do not risk being too much disturbed by the breaking up and scattering of the ice. On the other hand the seal wants flat, and not too thick ice to lie on, where it is easy to get up and down from the floes. The Greenland seal does not therefore like the old humocky Polar ice with high edges, but generally seeks ice which is only a few feet thick, *i. e.* such as is formed in the Norwegian Sea. There should not be much risk of the ice freezing together to form a solid ice-field; for, if this should happen, the seal could not get into the water. This does not happen as a rule on this tongue of ice, where there is sufficient movement to break the floes if they should freeze together. It nevertheless sometimes happens that the whole ice-mass does freeze solid, to the great misfortune of the seals, which are then

easily killed. It may also be mentioned that the great natural enemy of the seal, before it met with Man, was the bear; and there is less risk of meeting this enemy on the thinner ice in the outskirts of the great ice-masses, than in the interior regions; but nevertheless there are, as a rule, many bears present even here during the breeding season.

VI. The Formation of the Bottom-Water of the Norwegian Sea.

It is evident that the conditions required for the formation of the bottom-water of the Norwegian Sea, are that there shall be near its surface, water of salinity about 34.90 ‰, which by radiation of heat during the winter, may be cooled down to temperatures about -1.3 and -1.4°C .; thus it may obtain a density of between 28.11 and 28.13 or still higher, and become sufficiently heavy to sink.

It is only in places where Atlantic water has become somewhat mixed with Arctic water that there can exist conditions allowing of the production of water of salinity about 34.90 ‰¹, and of a temperature sufficiently low for the quantity of heat contained in the water, at the surface as well as in the underlying strata, to be no greater than can be gradually given off by radiation from the surface, and the whole bulk of water as a consequence cooled to below -1.2°C . during the winter and spring. It is necessary that there be no very rapid horizontal circulation, to bring in new supplies of warmer water. Such conditions are found in the northern Norwegian Sea, between Jan Mayen and Spitsbergen near the outer boundary of the East Greenland Polar Current, in the region of Amundsen's Stations 13—23, and towards the northeast in the region of Mohn's Stations 302 and 303². It was pointed out above that at the end of the winter there is in this region a maximum of density, and it is probably the centre of a great cyclonic movement of the northern Norwegian Sea. West and north of this region, inside the polar current, the underlying warm water is protected against cooling, as was mentioned above, by ice and the overlying layer of cold but much lighter Polar water. East of this region are the waters of the warm Atlantic Current (Gulf Stream) of high salinity but holding

¹ If the salinity of the surface-water is below 34.90 ‰ at the beginning of the winter, the formation of ice may increase it appreciably, as it does in the Barents Sea (see above p. 31); and besides, by vertical circulation there will result an intermixture between the waters of the upper strata, and the surface salinity be raised.

² In the sea between Jan Mayen and Iceland there may possibly be similar conditions during the winter, as seems to be indicated by the observations at Ryders Stations II and III (see above Chapt. V), in June, 1891.

too great a quantity of heat and having too rapid horizontal circulation to make it possible for the whole bulk of water to be cooled sufficiently by radiation to attain a density as high as that of the underlying bottom-water. No bottom-water can therefore, as a rule, be formed in these regions, and the same is also the case in the regions towards the south.

It is of interest to examine what may probably occur during the winter at a place like Amundsen's Station 14, which is the place where the bottom-water was found nearest the surface. The surface-water with a salinity of 34.39 ‰ would be soon cooled down below -1.5°C . (its freezing point is at -1.875°C .) and become heavier than the underlying water. It would sink and be replaced by somewhat warmer water with higher salinity. But this new surface-water will be cooled down in its turn till it becomes heavier than the previous surface water; it will sink still deeper and be replaced by warmer water with a still higher salinity from below¹. In this manner the salinity of the uppermost strata will be continually raised and approach that of the bottom-water (about 34.9 ‰); the depth of the vertical circulation will increase until it becomes operative through the upper lighter strata and reaches down into the typical bottom-water. All strata, from the surface downwards, will then have attained a nearly uniform temperature, salinity, and density². After this the cooling at the surface will produce such heavy water that it may sink far down into the bottom-water and even to the bottom itself.

As the water which is to form the deepest and coldest layers of the bottom-water has to sink down through all intermediate layers, it must be expected that the temperature of this bottom-water, when first formed at the surface and before beginning to sink, is lower than the lowest temperatures observed near the bottom. It must be remembered that the temperature of the water cannot but rise slightly during the sinking, for it has to pass through strata with slightly higher temperatures, with which it will be more or less intermixed, and the

¹ If ice be formed on the sea-surface, the salinity will be more rapidly increased; but if this ice remain, and form a continuous cover gradually growing in thickness, the cooling of the underlying water will be restrained considerably (see above p. 81).

² The writer has observed that a layer with an almost uniform temperature and salinity is formed in this manner down to 20 and 25 metres in the North Polar Basin; during the winter; but there, the vertical circulation cannot reach deeper, during one winter, owing to the rapid rise of salinity downwards. (Cf. Nansen, *Oceanography of N. P. Basin*).

temperature will also further be slightly raised by compression, at the greater depths.

It must consequently be expected that fairly uniform low temperatures of about or below -1.3°C. , will be found in the region where the coldest bottom-water arises and while its formation is going on. This is to some extent the case at Amundsen's Stations, especially those of them which were taken first in the season¹. But it seems to have been still more the case at Mohn's Station 302, where the following temperatures were observed:

Mohn's Station 302, July 19, 1878.

Depth	Temperature	Depth	Temperature	Depth	Temperature
0 metres	3.0°C.	55 metres	-1.0°C.	183 metres	-1.3°C.
18 "	3.0° "	73 "	-1.1° "	366 "	-1.4° "
37 "	0.0° "	91 "	-1.0° "	3630 "	-1.48° " ²

The three latter of these observations (at 183, 366, and 3630 metres) were taken with a Negretti and Zambra reversing thermometer, and may therefore be expected to be fairly trustworthy, although probably somewhat too low, like most Mohn's temperatures for the deep strata of the Norwegian Sea.

Both Amundsen's and Mohn's observations were, however, taken some months after the cooling at the surface had ceased; and consequently it cannot be expected that the original conditions would be found still existing; for it is clear that the heavy water produced by the cooling,

¹ The fact that the surface-salinities in the region of Amundsen's Stations 13—23 were rapidly decreased during the months of June and July, 1901, (as is proved by Amundsen's numerous observations as well as by those of the *Capella*, see above p. 15) indicate that earlier in the spring the surface salinities had probably been still higher, and must then have been at least very near 34.9°_{100} . After the above was written, however, Helland-Hansen and the present writer, for their memoir on the Norwegian Sea have examined several series of surface observations taken in the years 1901—1904, by several Captains of Norwegian sealing vessels, and it was found that in March, April, and even May, the surface salinity is always, without exception, very high in the very region of Amundsen's Stations. It is as a rule about 34.9°_{100} , whilst the temperature is very low, generally near the freezing point of the sea-water (-1.9°C.). This is conclusive evidence that the above explanation of the origin of the bottom-water of the Norwegian Sea is correct (see B. Helland-Hansen and F. Nansen, *Report on Norw. Fishery and Marine Investigations*, vol. II, No. 2).

² This temperature was observed with the Negretti and Zambra reversing thermometer. Two observations were also made at the same depth with two other less trustworthy thermometers (one Miller-Casella and one Casella-Buchanan) which gave very improbable values.

must sink deeper and deeper, gradually to approach a position of equilibrium, whilst near the surface the heavy water will be replaced by lighter water coming in laterally.

Summary. The process according to which the heavy bottom water is formed must consequently be the following: the heavy surface water cooled down to a density greater than 28.10 must sink, but as long as the surface cooling continues, new heavy water is continuously formed to replace it and sink in its turn. The water probably does not sink in vertical direction, but spreads out laterally, and finds its way in under the lighter cold water of the Polar Current towards the west and north, as also in under the lighter warmer water of the Atlantic Current towards east and south.

Warm water runs in everywhere under the cold toplayer of the Polar Current where-ever there is a chance, and forms the intermediate warmer layer between the cold polar water and the underlying bottom-water, having a density just between those of these two waters. But the intermediate warm water-layer is kept out in the above region whilst the formation of bottom-water is going on near the surface because this sinking water is heavier, at all depths from the surface downwards. There is consequently no room for the warm intermediate water to run in, and it would have to rise to the surface, where however, it will be cooled down and transformed into cold bottom-water.

As soon as the cooling at the surface ceases in April and May, no more cold water is formed to replace that which sinks, and lighter water will consequently be found in its place near the surface. The later the date of observation in the warm season, the deeper will therefore the isotherms of -1°C. and -1.2°C. and the isopycnal of 28.10 probably be found. For it is clear that conditions like those seen *e. g.* in Section IX (Pl. X), at Amundsen's Stations 20, 21, and 13, cannot be stable, and they cannot last long unless there is some external source of continuous renewal; the isopycnal of 28.10 is too steeply inclined towards both sides. This heavy water must evidently sink to greater depths and spread out towards the sides, in endeavouring to attain a position of equilibrium. The sinking of the isopycnal towards a position of equilibrium will continue during summer, and autumn until the cooling at the surface during the winter has again reestablished the former conditions¹.

¹ Prof. O. Pettersson (*op. cit.*) believes that the bottom-water of the Norwegian Sea is Polar water coming from the North Polar Basin with the East Greenland Polar Current, but its low temperature and comparatively high salinity prove that this is impossible. Besides, if the cold heavy water at Amundsen's Stations were actually moving southwards from the North Polar Basin it would be extremely difficult to ex-

It must consequently be expected that great alterations in salinity and temperature will take place at the surface in this region from summer to winter, and temperatures during the winter and spring will be found to be very low.

In the winter and spring of 1882, when the writer visited the sea between Jan Mayen, Spitsbergen, and Bear Island, the ice masses extended unusually far towards the east. The following temperature-series were taken, (with a Negretti and Zambra Reversing Thermometer) near or inside the margin of the floating ice-masses.

Series of Water-Temperatures taken, in March and April, 1882.

Depth in		March 28 ¹	March 28	April 5	April 10	April 24 ¹
Metres	Norwegian Fathoms	74° 55' N. Lat. 4° 53' E. Long.	7 hours later ²	74° 8' N. Lat. 10° 30' E. Long.	73° 4' N. Lat. 13° 24' E. Long.	73° 10' N. Lat. 11° 10' E. Long.
		—0.1° C.	—8° C.		—6° C.	
Air	Air	—0.1° C.	—8° C.		—6° C.	
0	0	—1.6 C.	—1.7° C.	—1.7° C.	1.8° C.	—1.9° C.
19	10	—1.4 "	—1.6 "	—1.7 "		
38	20	—1.6 "			2.2 "	1.7 "
57	30	—1.3 "		—1.7 "		
75	40					—1.4 "
94	50	—1.0 "		—1.7 "		
113	60					0.3 "
151	80					0.4 "
188	100					1.7 "

The water-samples taken at these stations, and brought home in sealed glass-tubes for chemical research, got lost in the laboratory where they were going to be examined, and their salinities were thus unfortunately never determined.

The Station on March 28, 1882, was taken about 8 naut. miles south of Mohn's Stat. 304 where the following temperatures were found on July 20, 1878, at about the same depths:

plain why this water is not deflected more towards the Greenland coast by the Earth's rotation; and how it is possible for an intermediate layer of warm water, moving southwards, to occur between this heavy water and the coast. It would be necessary to assume that this intermediate warm water had made the circuit of the North Polar Basin, north of the region from which the cold heavy water comes.

¹ Professor Mohn gives the temperature series of these two stations in his memoir on the Norwegian Sea (*op. cit.* p. 95) but he has reduced the temperatures by —0.1° C. It is probable however, that the above values are more accurate. He has also altered the reading for 20 fathoms on April 24, 1882, to — instead of + (and gives —2° C).

² An ice-crust was then being formed at the water-surface.

Depth	Mohn July 20, 1878	Nansen March 28, 1882	Difference
0 metres	3.6° C.	-1.6° C.	-5.2° C.
18 "	1.8 "	-1.4 "	-3.2 "
37 "	-0.9 "	-1.6 "	-0.7 "
55 "	-0.9 "	-1.3 "	-0.4 "
73 "	-0.4 "	[-1.1 "]	[-0.7 "]
91 "	-0.5 "	-1.0 "	-0.5 "
Mean	0.45 "	-1.23 "	-1.68 "

The Station of April 5, 1882, was about 22 kilometres west of Dr. Hjort's Station 64 of Sept. 6, 1900 (the Michael Sars). Hjort's salinities, at this place, varied between 35.02 ‰, at the surface and 20 metres, and 35.10 ‰ at 100 metres.

His temperatures were the following:

Depth	Hjort Sept. 6, 1900	Nansen April 5, 1882	Difference
0 metres	4.8° C.	-1.7° C.	-6.5° C.
20 "	4.79 "	-1.7 "	-6.5 "
40 "	3.35 "	-1.7 "	-5.05 "
60 "	3.25 "	-1.7 "	-4.95 "
80 "	[3.0 "]	[-1.7 "]	-4.7 "
100 "	2.90 "	-1.7 "	-4.6 "
Mean	3.68 "	-1.7 "	-5.38 "

Hjort's Station 64 was taken near the time of temperature maximum for the upper water-strata, and 48 days later in the season than Mohn's Station 304. It is, therefore, natural that there should be a greater difference between his summer- and the writer's winter temperatures. But the difference is still too great to be explained simply by cooling during the winter; there has in addition probably been some great displacement of the cold surface waters towards the east during the winter and spring of 1882, since the ice was met with much farther east than is generally the case. Whether "Bottom-Water" actually was being formed at the surface at my Station of April 5, 1882, cannot be decided as the salinity is unknown; it is indeed not impossible but it seems more probable that the low temperatures down to 94 metres belonged to a layer of less saline water, and that higher temperatures would have been met with in the water underlying.

But howsoever this may be the above vertical temperature series which are also the only ones existant from this region of the sea for winter and early spring, indicate what great amplitudes may occur there in the upper water-strata, between summer-maximum and winter-minimum.

They also demonstrate what great changes may take place in the water-masses of these regions in the winter, and it furthermore seems probable that the position and extension of the area of formation for cold "Bottom-Water" may differ much in different years.

*Temperature and Circulation in the Bottom-Water of the
Norwegian Sea.*

As no agencies exist which can lower the temperature of water at the bottom after it has once sunk below the sea-surface, whilst on the other hand the internal heat of the Earth will raise its temperature very slowly after it has reached the bottom¹, the lowest temperatures of the bottom-water will be most likely found near the region where it is formed; and this seems also to be the case actually.

In the southern part of the Norwegian Sea, between Norway, Iceland, and Jan Mayen, the temperature near the bottom, at depths of 2000 and 3000 metres, is about -1.1° C. according to the observations made during the cruise of the "Michael Sars" in 1900. In the sea between Iceland and Jan Mayen and east of Iceland, the Ingolf Expedition found bottom-temperatures of about -1.0° C. and -1.1° C. at depths between 1800 and 2500 metres². At Station 18 of the Michael Sars, in 1900, between Iceland and Jan Mayen, the bottom temperature was -0.94° C. At Dr. Hjort's Stations 64 and 65 (in September 1900) west and southwest of Bear Island, the bottom-temperatures seem to have been about the same, or perhaps slightly lower³. At Amundsen's Stations 15, 16, 20, and 23, where the observations go down to 2000 metres, the temperatures were lower, about -1.3° C. (according to the observations taken with the most trustworthy instrument, Richter Reversing Thermometer No. 113) and the probability is that similar temperatures would have been found near the bottom⁴. It is therefore evident that the temperature of the bottom-water is appreciably lower at all depths

¹ Cf. Nansen, *Oceanography of N. P. Basin*, pp. 341 *et seq.*

² See M. Knudsen, *Hydrography, The Danish Ingolf-Expedition*, vol. 1, No. 2, Copenhagen 1899.

³ The temperatures were taken with the Pettersson-Nansen Insulated Water-Bottle, and cannot be corrected sufficiently accurately.

⁴ Prof. Otto Pettersson believes (*op. cit. Geogr. Journal*, vol. XXIV, p. 317) that the present writer's assumption of a temperature for the deep of the northern Norwegian Sea of "probably about -1.3° C. or -1.4° C." rests upon Mohn's deep soundings in 1878, and is therefore uncertain. As is seen above, this is a mistake, the assumption in question rests upon Amundsen's observations, which are also the most trustworthy hitherto published from this region.

in this region, than in any other part of the Norwegian Sea, hitherto investigated with modern instruments¹.

The circulation of the bottom water in the Norwegian Sea cannot be described in detail. As was pointed out above, it is chiefly formed and sinks towards the bottom during the winter and spring in the regions between 73° and 76° N. Lat., and between 4° W. Long. and 4° E. Long. From this region it moves along the bottom and spreads out laterally producing perhaps several cyclonic movements in the deep strata of the Norwegian Sea. During this circulation it is very slowly heated from the underlying warmer bottom, and also slightly from the overlying warmer water, chiefly by convection. In this manner its temperature near the bottom is gradually raised from about -1.3° C. to about -1.1° C. and perhaps -1.0° C.

It seems hardly probable that the bottom-water flows directly southwards by a single cyclonic movement, from the region of its formation along the western slope of the deep basin towards the Færoe-Iceland Ridge, thence eastwards along its northern slope, and northwards again along the eastern slope of the basin. For if it be assumed that a layer of bottom-water, about 500 metres thick, has been heated as much as 0.1° C., by the subterranean heat of the Earth, on its way from 73° N. Lat. to 64° N. Lat., north of the Færoe Islands it means that the water has spent perhaps 50 years on this distance, or in other words that it has moved with an average velocity of about 0.64 mm. pr. second.

¹ At Ryders Station X a temperature of -1.3° C. was observed at 1830 metres (1000 fathoms). At his Stat. IX the observations gave -1.2° C. as being the temperature of the bottom-water below 1130 metres (600 fathoms).

Previous expeditions have on the whole obtained very low temperatures for the bottom-waters of the Norwegian Sea. This is, for instance, the case with the Norwegian North Atlantic Expedition, whose bottom-temperatures seem to be on the whole one or two tenths of a degree too low; and in some cases even more, *e. g.* at Stat. 302, where Mohn gives a bottom-temperature of -1.7° C., whilst his Negretti and Zambra reversing thermometer gave -1.48° C. which is more probable, although perhaps even that is somewhat too low. But Mohn's numerous bottom-temperatures show a marked tendency to sink towards the region of his Stations 302 and 303, and of Amundsen's Stations (see Mohn, *op. cit.* Pl. XXV). Mohn has, however, had a theory that the bottom-temperatures should be especially low below the East Greenland Polar Current, and he drew his bottom isotherms accordingly, which has led to a somewhat misleading picture. *E. g.* bottom-temperatures as low as -1.4° and -1.5° C. do certainly not exist in the sea between Jan Mayen and Iceland. The bottom-temperature there is about -1° C. according to the Ingolf Expedition, and -0.94° C. at Stat. 18 of the "Michael Sars" (Aug. 1900) further west, and at Stat. 19 nearer Jan Mayen it was -0.88° C. at 1300 metres. Ryder found the temperature near the bottom at his Stations II and III (between Iceland and Jan Mayen) to be -1.0° C., and -1.1° C. at Stat. IV, at a depth of 1830 metres.

This is an extremely slow movement; and inasmuch as no appreciable difference has been observed between the bottom-temperatures on the eastern and western sides of the deep basin to the south of the latitude of Jan Mayen, it seems probable that the bottom-waters really move with much greater velocities and that the movements of the water are much more complicated. There may be several vortices of cyclonic or anticyclonic movement near the bottom, perhaps one in the southern part of the Norwegian Sea, south of 70° N. Lat., and one or more in its northern part, between Jan Mayen, Spitsbergen, and Greenland.

Renewal of the Bottom Water of the Norwegian Sea.

It might seem somewhat astonishing that the great bulk of bottom-water, filling at least two thirds of the whole basin of the Norwegian Sea, should originate from such a small area as that above indicated; but the actual renewal of the cold bottom-water in this basin must be an extremely slow process. The Bottom-Water does not extend across the ridge anywhere between Iceland and Norway, as is easily seen by examining the temperature on the Iceland-Færoe-Scotland Ridge, which is nowhere below zero. This is fully proved by the numerous soundings taken by the Danish, Scottish, and Norwegian expeditions during the last five years. It is also very improbable that any bottom-water with a temperature below -1° C. ever gets across the ridge between Iceland and Greenland. No Stations taken by the Danes, or during the expedition with the "Michael Sars", in 1900, indicate any very cold water near the bottom in this region.

Capt. Ryder took one sounding (Stat. XXVIII, Aug. 1892), between Iceland and Greenland, in $67^{\circ} 19'$ N. Lat. and $25^{\circ} 3'$ W. Long., which is north of the ridge, and he found at a depth of 1280 metres (700 fathoms) a bottom temperature of -0.6° C.

During the Danish *Ingolf-Expedition*, in 1895 and 1896, a great many Stations were taken in the sea between Iceland and Greenland, but most of them were on the southern side of the Iceland-Greenland Ridge, and gave comparatively high bottom-temperatures, above 1° C. with the exception of Stat. 12 (in $64^{\circ} 38'$ N. Lat., $32^{\circ} 37'$ W. Long.) where the bottom-temperature was 0.3° C. at a depth of 1958 metres which would seem to indicate that in this region there may have been some southward outflow of cold bottom-water across the ridge to the north. Stat. 15 was on the ridge, at $66^{\circ} 18'$ N. Lat., $25^{\circ} 59'$ W. Long., and gave a bottom-temperature of -0.75° C. at 621 metres, the lowest bottom-temperature observed in

this region. During the cruise with the "Michael Sars", in 1900, a series of temperatures (Stat. 13, Aug. 3, 1900) was taken to the north of this Station, in $66^{\circ} 42'$ N. Lat., $26^{\circ} 40'$ W. Long., and a temperature of 0.14° C. at the bottom in 550 metres found.

North of Iceland the Ingolf expedition found a bottom-temperature of -0.8° C. at Stat. 125 in $66^{\circ} 8'$ N. Lat., $16^{\circ} 2'$ W. Long.; depth 1373 metres¹.

Near the Greenland coast, in Denmark Strait, Axel Hamberg observed in 1883 nothing but warm water under the Polar Current, and the temperature was about 3° C. near the bottom². It is thus seen that at no place hitherto examined, does bottom-water with a temperature below -0.8° C. exists on or near the Iceland-Greenland Ridge, while on the Iceland-Færoe-Scotland Ridge the bottom-temperatures are even much higher. There is therefore hardly any possibility that bottom-water with a temperature below -0.8° C., or perhaps even 0° C., can get out of the Norwegian Sea and southwards. It is necessary to assume that the bottom-water circulates in the deep basin of this sea, until it shall have become warmed up towards zero chiefly by intermixture with the overlying warmer water; it may then be carried out, chiefly across the ridge in the Denmark Strait, under the polar current. But no great quantity can be carried out of the basin, and it is at once obvious that the renewal of the Bottom-Water of the Norwegian Sea in this way must be an extremely slow process. The quantity of cold water formed at the surface and sinking to the bottom during the winter, in Amundsen's region, between Jan Mayen and Spitsbergen, may therefore be expected to be amply sufficient to feed this circulation.

¹ During the cruises of the „Fylla”, of the Danish Navy, in the summers of 1877 and 1878, several series of deep-sea temperatures were taken in the sea west and north-west of Iceland. (See Hoffmeyer, *Geografisk Tidsskrift*, Copenhagen, vol. II, 1878, p. 97, and Bardenfleth, *ibid.*, vol. III, 1879, p. 46). The thermometers used have, however, evidently given too low temperatures. In $66^{\circ} 25'$ N. Lat. and $25^{\circ} 50'$ W. Long. a bottom-temperature of -1.1° C. was observed at 650 metres (1878), and in $67^{\circ} 40'$ N. Lat., $22^{\circ} 23'$ W. Long., the bottom-temperature at 660 metres was determined as -1.6° C. which is an improbable value.

² Axel Hamberg, *Bihang till K. Svenska Vet. Akad. Handlingar*, vol. IX, No. 16 Shockholm, 1884, p. 13.

VII. The Bottom-Water of the North Polar Basin.

In the North Polar Basin the bottom-water has a minimum temperature of between -0.8° C. and -0.9° C. according to the observations made during the drift of the "Fram"¹. The salinity should, according to the deter-

¹ Professor Otto Pettersson (*Geograph. Journal*, London, vol. XXIV, 1904, pp. 317-318) appears to be somewhat doubtful as to the accuracy of the temperature determinations taken on the "Fram", and he even says that it is just as "possible that the temperature and salinity (of the bottom-water of the North Polar Basin) are lower than in the adjacent part of the Norwegian Sea as that they are higher". It is not quite clear how Pettersson can have got this idea. It was pointed out, in the Memoir on the Oceanography of the North Polar Basin, that the determinations of specific gravity (and salinity) are not as accurate as would have been desirable; this is to be ascribed to the inherent defects, of the methods then generally in use. But, as will be mentioned latter, there is no possibility whatever that the salinity of the bottom-water of the North Polar Basin, is lower than that of the Norwegian Sea. The inaccuracies of the determinations of specific gravity, when treated in the way employed below, are not greater than, for instance, the inaccuracies of the salinities which Pettersson has published in the series of observations from Arrhenius's Stations in 1896, and the Stations of Kolthoff's expedition with the Frithjof, in 1900; the values obtained, inasmuch as none of them are accurate, are so far fairly comparable. The only observations of salinities, hitherto published from the northern part of the Norwegian Sea, to give a considerably higher order of accuracy, are those of Amundsen in 1901; and the observations of Dr. Hjort, on the "Michael Sars", east of Bear Island and Spitsbergen in 1900 and 1901.

As to the *temperatures* observed in the North Polar Basin even they are not as accurate as they ought to be, but they are at any rate much more accurate than, for instance, those published from Arrhenius's Stations in 1896 and Kolthoff's Stations in 1900 (where there are evident errors exceeding 0.5° C., or at some of Arrhenius's Stations even more than 1° C.). The errors in the final (*op. cit.*, pp. 244-256) temperature values of the bottom-water in the North Polar Basin cannot, at any rate for the series from the summer-months, be more than $\pm 0.1^{\circ}$ C. but are probably in most cases much less, as is proved by the conformity between the observations at different depths and at different Stations. Pettersson does not apparently approve of the use of "probable corrections". It would certainly be a great advantage if the zero-corrections of the instruments used could be accurately determined before and after each series of observations, but this could not be done during the Fram-expedition, as there was no pure snow or ice available for it; and then there is no other course to follow than to use "probable" corrections, if any probable results at all are to be obtained. Prof. Pettersson mentions (*loc. cit.* p. 317) as an example to prove the probable inaccuracy of our temperature-determinations Dr. Blessing's observation from 1900 metres at Stat. 24, on Dec. 2, 1895, where the reading was -0.65° C. (*Oceanography of N. P. Basin*, p. 131). Pettersson thinks that according to the very careful and complete information given in the Memoir about the thermometer used (Negretti and Zambra Reversing Thermometer No. 75,680) it must be regarded as uncertain whether this reading should after correction, indicate a temperature of -1.05° C., or -0.77° C., or -0.71° C., or -0.65° C. As it is important to know whether Pettersson's doubt is justified, and just how far these observations are trustworthy, it is worth while making the following remarks here, whilst at the

minations, be about 35.1 ‰ (computed by means of Knudsen's tables, see below). This water is consequently different from the bottom-water of the Norwegian Sea, if these determinations be correct. For this reason it was assumed by the writer that there could be no open communication between the deep basin of the North Polar Sea and that of the Norwegian Sea; otherwise the heavy bottom-water would flow into the latter.

same time referring the reader to the original Memoir now in question (Oceanography of N. P. Basin, pp. 40-58, 237-242).

The instrument used (N. & Z. No. 75,680) had a correction of $+0.07^{\circ}\text{C}$. in May 1893, and of $\pm 0.00^{\circ}\text{C}$. in March 1898. The diminution of the correction is evidently due to the secular contraction of the glass, and it may consequently be expected that the actual error of the instrument had been somewhere between these limits during the expedition if the thermometer had not been lying, when out of use, in a room with low temperature. By comparison with another thermometer (N. & Z. No. 75,684, the zero-corrections of which were determined in May 1893, in October 1900, as well as by numerous comparisons with other thermometers during the expedition) it was found, however, that the correction was -0.06°C . on July 29, 1895, and this was accepted as the probable one for that year, although in reality it might possibly have been anywhere between this and $\pm 0.00^{\circ}\text{C}$. But the inaccuracy thus arising cannot consequently amount to many hundredths of a degree and the correction will on the whole tend to give a too low temperature. On February 5, 1896, Dr. Blessing determined the zero-correction of this instrument to be -0.4°C . but as he himself says (see Oceanography etc., p. 58, foot-note) the method used for the determination cannot have been trustworthy. The method employed is described in the Memoir (p. 238); as is there pointed out it must inevitably have given a minus-corrections at least 0.28°C . too big, and thus the zero-correction found by Blessing on February 5, 1896, cannot at any rate have been greater than -0.12°C . But as Blessing himself says the determination cannot have been trustworthy, because he had to "keep the thermometer in his hand" while it was being reversed, (and consequently had to lift it out of the melting hoar-frost into the warm air before reversing); the real error was therefore less, and therefore approaching the error actually assumed. It is a well-known fact that if the zero-point determination be not very carefully done, a much too great minus-correction is generally obtained. Pettersson's assumption that the zero-correction of -0.4°C . found by Blessing may have been correct, is consequently very improbable. There is, however, another circumstance, which might tend to make the temperature-readings too low, in cases like that mentioned by Pettersson, *viz.* that the temperature of the air on the day in question was low, -40°C .; but this, the only possible cause of an appreciable inaccuracy, is not mentioned by Pettersson. If the thermometer, after coming up from the water, had had time to assume the air-temperature before the reading was taken, its indication would have to be corrected by about $+0.55^{\circ}\text{C}$. The thermometer was, however, as a rule kept below the water-surface, until convenient for taking the reading, it was then hauled up and read off as soon as possible; but as this had to be done with a lens, and during the dark winter (as on the above occasion) by the light of a lantern, it might take some time; thus the broken off mercury might have been somewhat cooled in the air, and accordingly have given too low indications. In making the corrections, however, it was assumed that the thermometer had only been cooled down to the temperature of the upper water-strata, and in the case mentioned by Pettersson the reading was therefore reduced by -0.04°C . and a temperature of -0.69°C . thus obtained for 1900 metres on Dec. 2, 1895. *Consequently the real temperature cannot have been lower than this value, provided that the thermometer was correctly read off, but there is a possibility or even a probability that it may have been somewhat higher.* As already pointed out, the deep-sea temperatures taken with the re-

If it be assumed that the true salinity be only 35.00 ‰ its density (σ_t) at -0.9°C . would be about 28.17, and if the salinity be 35.10 ‰ the density would be 28.25. At that time it therefore seemed necessary to assume that this particular bottom-water was from the intermediate warmer strata (between 250 and 700 metres) which had been cooled down to its lower temperatures somewhere in the still unknown parts of the North Polar Basin itself. But this sea is covered by a layer, at least 200 metres thick, of lighter cold water of very low salinity, decreasing upwards from about 34.7 ‰, at 200 metres, towards 30 ‰ or 32 ‰ at the surface. It seemed therefore hardly probable that water with a salinity of about 35 ‰, could occur near the surface anywhere inside the area of this sea¹. It was therefore thought that the only way in

versing thermometers on cold winter-days may have a tendency to be too low; and the series of temperatures taken during the summer, on days when the temperature of the air was very nearly the same as that of the water, are therefore the more trustworthy. The final values of these series, given in the Memoir pp. 244—256, may be expected to have a fairly high degree of accuracy, at least as compared with those of most other expeditions. The writer thinks that especially the series of temperature taken in June and August, 1894, and those taken in July, 1895, are very good. As the conditions are so extremely uniform, especially in the deep layers of this basin, as proved by all the observations, these series give very reliable information about the vertical distribution of temperature in the bottom-water of that sea, and as it is known that the density of this bottom-water must be very nearly uniform at the same levels throughout the whole basin, there cannot possibly be much difference in the temperature of the deep layers in any other part of it; unless it be assumed that the salinity also differs much which is highly improbable.

It must therefore be assumed that hardly anywhere in the North Polar Basin can the minimum temperature of the bottom-water be much below -0.9°C .

In the connection a temperature reading of -1.14° , on October 27, 1894, for 2500 metres may be mentioned here. Corrected by the instrumental error and error by cooling in water (-0.04 , see l. c. pp. 241—242), this reading would give a temperature of -1.18°C ., which is, however, an impossible value since a temperature of -0.84°C . at 3000 metres was observed on the same occasion, it would give the water a too high density, and would make it sink rapidly to the bottom, unless it be also assumed that just at this one depth the water happened to have been of a salinity much lower than that of the bottom-water as found at all other Stations in the Polar Basin; which is hardly possible. The air-temperature on that day was -33°C ., with a wind of 3 metres per second; and it is clear that the thermometer has been exposed too long to the air before being read off; the broken off mercury was cooled down some twenty degrees to that the correct temperature must have been between -0.8 and -0.9°C . If the mercury had had time to assume the air temperature, the reading corrected for instrumental error should have been reduced by $+0.45^\circ\text{C}$. which would have indicated a temperature of -0.73°C ., and that is evidently too high. (In the footnote about this temperature-reading, *op. cit.*, p. 252, there is a mistake, the reading being stated to be -1.24°C ., instead of -1.14°C .).

¹ The only possibility would be that north of Spitsbergen and north of Novaya Zemlya, the vertical circulation during the winter, might give the surface water a comparatively high salinity (see later).

which the bottom-water could be cooled down to -0.8°C . and -0.9°C . would be by contact with the overlying cold water-stratum. But along the "Fram's" route the cold bottom-water was separated from the cold top-layer by an intermediate warmer layer 600 or 700 metres thick, where the temperatures were above zero. It seemed very difficult to understand that in the still unknown parts of the basin there could be such entirely different conditions, that the whole bulk of thick warm water could be cooled down to -0.8°C . merely by contact with the overlying layer of cold Polar water, and that in this unknown region, the temperature would, from the surface to the bottom, at all depths be below -0.8°C . This cooling could not, to any great extent, be caused by intermixture with the overlying less saline strata, for the salinity would be thus too much reduced. It seemed extremely difficult to conceive, that such a great bulk of water, so well protected against cooling by direct radiation from the surface, by an overlying lighter water-stratum, could be so much cooled down chiefly by convection. It would seem to require a quite unreasonable length of time.

Nevertheless no other explanation was apparent¹; since the salinity, as also the temperature, was too high to make it seem likely that this bottom-water could have come from the Norwegian Sea. But the more it is considered the greater appears the difficulty in understanding how the bottom-water of the North Polar Basin can actually be cooled down to -0.8°C . and -0.9°C . while under a thick protecting cover of lighter cold Polar water; it seems utterly impossible². If, therefore, there be any possibility, in spite of the determinations, that the salinity of the bottom-water is as low as about 34.93 ‰ it would be a much simpler and more probable explanation to assume that the bottom-water of the North Polar Basin, is formed in the same region as the bottom-water of the Norwegian Sea; further, that it flows thence into the North Polar Basin, underneath the intermediate warmer layer, just as it flows along the bottom southward into the southern part of the Norwegian Sea, and is slowly heated on the way by the subterranean heat of the Earth as well

¹ Oceanography of N. P. Basin, pp. 337 *et seq.*

² Prof. Pettersson (*Geogr. Journ.* vol. XXIV, pp. 318, 320) has adopted the writer's previous theory that the cold bottom-water of the North Polar Basin is originally water of the intermediate warmer layer which has been cooled down to a lower temperatures; and he thinks that this cooling might be effected by melting of ice. Even if the ice did melt in the North Polar Basin in the manner assumed by Pettersson, which it does not (the ice is there always growing thicker from one year to another), his theory is impossible because there are no ice-bergs in the North Polar Basin, and the polar ice is much too thin to reach down into the warmer water-strata underlying the thick layer of lighter Polar water.

as by intermixture with the overlying warmer layers. The probability would then be that there is some kind of communication between the deep basins of the Norwegian Sea and the North Polar Sea; and that there can be no high ridge between Spitsbergen and Greenland as the writer assumed in the Memoir cited.

This ridge, if it exists, must in that case be very low, rising perhaps to depths where the bottom-water of the Northern Norwegian Sea, between Spitsbergen and northern Greenland, has a temperature of about -1°C . This low ridge would then prevent the coldest bottom-water of the deepest basin in the Norwegian Sea from running into the North Polar Basin. It has, however, been seen that the bottom-water is probably heated from about -1.3°C . to about -1.1°C . on its way from 74°N. Lat. to the southern part of the Norwegian Sea. And a similar heating must be considered likely on the much longer way through the North Polar Basin, which must be considered as like a great fjord, where movement of the deep water is extremely slow. The higher temperature is, therefore, no hindrance in the way of assuming that the bottom-water of the latter is the same as that of the Norwegian Sea. It is only the higher salinity which seems to stand in the way of accepting the above explanation.

The writer has, therefore, again examined whether there is no possibility that the values of salinity in the North Polar Basin, as given in the Memoir, are not in spite of every possible care much too high¹. All his own observations made with the hydrometer, in 1894² have been revised and the readings corrected for the absolute minimum and maximum corrections³ of the instrument (Hydrometer Åderman No. 2). The values of specific gravity ($S \frac{17.5^{\circ}\text{C.}}{17.5^{\circ}\text{C.}}$) and salinity have been computed by means of Knudsen's Tables⁴.

¹ *Op. cit.* pp. 146 *et seq.*

² *Op. cit.* pp. 168—184.

³ *I. e.* the instrumental errors at maximum and minimum of surface-tension of the sea-water. *Cf. op. cit.* p. 330.

⁴ The coefficient of thermal expansion for the glass of the hydrometer has been assumed to be between 0.000026 and 0.000028.

As stated in the memoir, the salinities, computed from the specific gravity ($S \frac{17.5^{\circ}\text{C.}}{17.5^{\circ}\text{C.}}$) by Tornøe's formula [$\text{Salinity } \text{‰} = \left(S \frac{17.5^{\circ}\text{C.}}{17.5^{\circ}\text{C.}} - 1 \right) 1315$] are, for values about 35.0 ‰ , about 0.16 ‰ higher than the values obtained from the same specific gravities by Knudsen's Tables. If the observations with the hydrometer be computed by Knudsen's Tables, they will, however, also give somewhat lower specific gravities than published in the memoir; this is especially the case with observations taken at somewhat low temperatures. And thus the final values of the salinity will be still more reduced.

It has then been found that at depths between 350 and 3000 metres the values of the salinity must have been between the following upper and lower limits, on the dates mentioned:

Date 1894	Depth in Metres	Temperature	Salinity and Density			
			Lowest possible Value		Highest possible Value	
			‰	σ_t	‰	σ_t
June 26	350 m.	0°36° C.			35°12	28°20
Oct. 18	400 "	0°76 "	34°96	28°05		
June 26	400 "	0°38 "			35°16	28°23
June 26	450 "	0°40 "	35°01	28°12		
Oct. 18	450 "	0°72 "	35°10	28°17		
June 26	600 "	0°18 "	34°96	28°08		
Nov. 3	700 "	—0°13 "			35°11	28°22
June 27	800 "	0°01 "			36°16	28°25
June 27	1200 "	—0°34 "			35°11	28°23
Apr. 26	1400 "	—0°44 "	35°08	28°21		
June 27	1600 "	—0°58 "			35°11	28°24
Oct. 27	2500 "	—0°89 "	34°99	28°16		
Oct. 29	3000 "	—0°84 "	35°10	28°25		

If the bottom-water of the North Polar Basin with temperatures below zero, has a nearly uniform salinity, like that of the Norwegian Sea, this salinity must consequently, according to the observations, be between 35°08 ‰ and 35°11 ‰. As there seems to be no probable reason to doubt these determinations it appears at present, until new investigations shall have been made, necessary to assume that the salinity of the bottom-water of the North Polar Basin is about 35°10 ‰.

On November 30 and December 2, 1895, Dr. Blessing bottled several water-samples from depths between 150 and 900 metres in the North Polar Basin. These samples were brought home, and the specific gravity of five of them carefully determined by Mr. Hercules Tornøe with the Sprengel pyrometer¹. If the salinities be computed by Knudsen's Tables from the specific gravities thus obtained the following values for salinity and density, of the samples from 800 and 850 metres are obtained:

¹ Nansen, Oceanography of N. P. Basin, p. 214.

Depth	Temperature	Salinity	σ_t
800 m.	0°15° C.	34'99 ‰	28'11
850 "	—0°01 "	35'01 "	28'136

These values are, somewhat lower, than those found above¹; but the samples were taken with a water-bottle of Blessing's construction which can hardly have closed perfectly tightly². Some slight quantity of water from the upper water-strata may thus have come into the samples, and the salinities have become somewhat too low as a result. On the other hand there is also a possibility that they may have come out somewhat too high by reason of some slight evaporation through the glass stoppers of the bottles, while placed, for sterilisation, in boiling water for half an hour without however being heated to boiling point³. The glass stoppers were afterwards carefully soldered by paraffin-wax; and when the bottles were opened, in 1898, the paraffin was still in perfectly good condition; no considerable evaporation is therefore likely to have occurred. There is therefore on the one hand a possibility that the salinities may have been somewhat higher than indicated by determination of the above samples; it may on the other hand have been slightly lower. And if the latter has been the case, the salinity of the

¹ By computing the salinity according to Knudsen's Tables Prof. Pettersson (*l. c.* pp. 316—318) comes to the conclusion that there was a considerably higher salinity (of 35'10 ‰) at 450 metres than between 800 and 900 metres of the same station. It was, however, pointed out (*op. cit.* p. 213) that the determination of the sample from 450 metres was made by Dr. Heidenreich by means of an ordinary Specific Gravity Bottle with inserted thermometer, and was not sufficiently accurate. It was necessary first to reduce his somewhat inaccurate values of $S \frac{17.5^\circ \text{C.}}{17.5^\circ \text{C.}}$ by a probable error of 0'00006 (= 0'078 ‰ salinity). But even after this reduction the value for 450 metres is improbable; for it will give the water at 450 metres a density (σ_t) of 28'17 (temperature = 0'73° C.) while the densities at 800 and 850 metres were according to the values above, about 28'11 and 28'136. The density at 450 metres cannot, at any rate, have been greater than these; the salinity therefore cannot have been above 35'04 ‰ and was probably lower, provided of course that the values obtained for 800 and 850 metres be correct. It is consequently seen that Pettersson is not on very safe ground in concluding from this one inaccurate observation that there was a higher salinity (of 35'10 ‰) at 450 metres, than at the greater depths.

It might be mentioned that the values of temperatures given in Pettersson's table *loc. cit.* p. 316) are not the final values (*op. cit.* p. 255); but are somewhat too low.

² It may be mentioned that the writer, some years ago made a water-bottle of exactly the same construction, which did not, however, close tightly, and therefore had to be altered.

³ Cf. Nansen, *op. cit.* p. 212.

bottom-water of the Norwegian Sea is approached as the correct value for these samples also.

Howsoever this may be, it is at all events quite impossible to say anything at all with certainty, about the salinity of the bottom-water of the North Polar Basin on the basis of Blessing's water-samples; whilst on the other hand the determinations made with the hydrometer make it impossible to estimate the salinity lower than 35.08 ‰.

The question now is: is there much chance of Warm Water with such a High Salinity running into the North Polar Basin?

The Atlantic water, carried into the North Polar Basin by the warm current along the west coast of Spitsbergen, cannot be heavier than the bottom-water of the Norwegian Sea; otherwise it would sink in the latter before it could cross the submarine ridge northwest of Spitsbergen. Its density (σ_t) must therefore be, at least somewhat, lower than that of the bottom-water, or lower than 28.10, at the time it crosses this ridge, and [the probability is that the density is even lower than 28.02 (see Pl. V, maps for 100—400 metres). The maximum salinity which the water can possibly have at that moment, will therefore depend on its temperature. If there be assumed for the upper limit of the density as much as 28.10 the highest possible salinity would be 35.25 ‰ at 3.0° C., 35.17 ‰ at 2.5° C., and 35.13 ‰ at 2.0° C. But if the upper limit of the density be 28.02 the maximum salinity would be 35.14 ‰ at 3.0° C., 35.09 ‰ at 2.5° C., and 35.04 at 2.0° C.

According to Mohn's Sections XXIV and XXV¹, off the north-west coast of Spitsbergen, the temperature of the warmest core of the current in August, 1878, was between 2° C. and 3° C., and mostly between 2° C. and 2.5° C. (see his Sect. XXV). The salinity must consequently, have been for the greater part at least below 35.17 ‰ and probably below 35.09 ‰. According to Arrhenius's Section (see Pl. X, Sect. IX) west of Northern Spitsbergen, in August, 1896, the warmest core of the current, with the highest salinities, had temperatures about 2.5° C.²; the salinity cannot at any rate have been above 35.17 ‰, and it has probably not been much above 35.09 ‰. The salinity of 35.22 ‰ (originally 35.29 ‰, see Pettersson and Ekman, *op. cit.*),

¹ Mohn, *op. cit.* Pl. XIII. Mohn's Section XXIII, westwards from Ice Sound on Spitsbergen, has remarkably low temperatures, and there appear to have been exceptional conditions in this region at the time the section was taken.

² See also the small Section north of Spitsbergen, Pl. X, Sect. IX a.

with a temperature of 2.46° C., in 400 metres at his Station IV, is consequently much too high; it would give the water a density of about 28.13 , and make it considerably heavier than the underlying waters¹.

According to information kindly afforded by Dr. Axel Hamberg, the Oceanographer of the Nathorst Expedition to Spitsbergen in 1898, the highest salinity observed in the warm West Spitsbergen Current during that summer, was 35.19 ‰, which on being reduced to the values of Knudsen's Tables, would probably be about 35.14 ‰. And this was only found in one water-sample; the salinities otherwise did not exceed 35.15 ‰, or reduced 35.10 ‰. This agrees fairly well with what might be expected on the basis of what has been pointed out above.

In Chapter IV it was proved that in the Barents Sea there is formed, during winter and spring, a very cold bottom-water which has a higher salinity than the warmer water in the same region of the sea. It was also pointed out that some of the cold bottom-water, formed in this same manner, may probably flow along the bottom into the North Polar Basin from the sea north of Novaya Zemlya. And this cold water, which has probably a very high salinity, may help to form the bottom-water of the North Polar Basin by being intermixed with some of the overlying warmer waters.

There is also a possibility that the water of the warm Atlantic Current with a salinity above 35.0 ‰, may be carried to the surface by vertical circulation during the winter, in the region north of Spitsbergen; and may be cooled down to about -1° C. or lower, just as in the Barents Sea, whilst the salinity may be somewhat increased by the formation of ice at the surface. At Arrhenius's Stations III—VI the surface-water had salinities between 34.5 ‰ and 34.82 ‰. Mr. Hercules Törnøe of the Norwegian North Atlantic Expedition found a surface-salinity of about 34.6 ‰² farther north on the very ridge, northwest

¹ It was already pointed out above (p. 59) that there are several discrepancies in the values of salinity and temperature for the different depths of Arrhenius's Stations, published by Pettersson and Ekman. For 850 metres at Stat. IV, there is given a salinity of 35.10 ‰, (which reduced would be 35.03 ‰) and a temperature of 2.05° C. Both salinity and temperature are much too high, the former was probably really near that of the bottom-water and the temperature near zero at that depth. At Stat. III the published values of temperature and salinity would give about the following densities, if the salinities be reduced by 0.07 ‰: In 40 metres 27.49 ; in 60 metres 27.89 ; in 80 metres 27.63 ; in 200 metres 27.89 ; in 300 metres 27.97 ; and in 500 metres 27.88 . A vertical distribution of density like this cannot exist in the Ocean, the observations from 60 and 500 metres at least, must be erroneous.

Hercules Törnøe, Chemistry, *The Norw. North-Atlantic Exp.* 1876—1878, p. 64.

of Spitsbergen, with a surface temperature of 5.2°C . (Mohn's Stat. 362, in $79^{\circ} 59'$ N. Lat., $5^{\circ} 40'$ E. Long.). In July, 1897, salinities of about 35.0‰ were observed on the sea-surface between 78° and 79° N. Lat. west of Spitsbergen, according to O. Pettersson and G. Ekman¹. It is evident, that if water with such comparatively high salinities be cooled down to freezing point during the winter, a very active vertical circulation will arise, which may break through the underlying warmer but more saline water and at last reach the bottom. Surface-water with a salinity of 34.82‰ , as at Arrhenius's Stat. IV, will have a density of 28.06 at its freezing-point (-1.90°C .), and water with a salinity of 35.0‰ will have a density of about 28.20 at its freezing point (-1.925°C .). It was pointed out above what great changes in Salinity and Temperature between Summer and Winter, may arise on and near the sea-surface in the Barents Sea and in the region of Amundsen's Stations 13—23, north of Jan Mayen. It would seem probable that similar great changes may also occur during the winter, in the sea north of the Spitsbergen coasts, and heavy bottom-water, like that of the eastern Barents Sea, might then be formed on the continental shelf in this region; its salinity would in that case be increased by the formation of ice at the surface. The heavy cold water thus resulting may sink, and flow northwards along the slope of the Continental Shelf, into the deep North Polar Basin, where after being gradually mixed with overlying warmer waters, it may contribute to the formation of the bottom-water.

Future investigations will finally have to decide whether the above value of about 35.10‰ for the salinity of the bottom-water of the North Polar Basin is too high². If this determination be confirmed, the possibility of a communication between the deep North Polar Basin and the deep basin of the Norwegian Sea, as well as of their bottom-waters, will be finally excluded. But in this case there are, as is shown above, two regions where the bottom-water of the North Polar Basin might originate, by being cooled down directly through radiation from the sea-surface, *viz.* in the seas north of Spitsbergen and near northern Novaya Zemlya.

It was stated above that only a small quantity of water was required yearly, to feed the circulation of the cold bottom-water of the Norwegian

¹ *Loc. cit.*, p. 38.

² Just one trustworthy water-sample at 1000 or 1500 metres, from the sea to the north of Spitsbergen, would be sufficient to decide this question. The writer has made several attempts to get such a sample taken by different expeditions, but hitherto without success, nor has he been able to find time to go and take it himself. It is to be hoped, that in the near future this much to be desired sample may be taken.

Sea, as its renewal is such an extremely slow process. But it must be expected that the renewal of the cold bottom-water of the enclosed North Polar Basin, which is like a great fjord, occurs still more slowly, and a much smaller quantity of water is required yearly, to feed the circulation of this water. It is therefore, not improbable that the cold waters, with high salinity, formed during the winter in the two above-mentioned regions, might be sufficient to maintain this circulation; and it is possible that this is a feasible solution for the problem of the origin of the heavy bottom-water in the North Polar Basin, in the case of the possibility of its coming from the Norwegian Sea being excluded.

P. S. In 1904 Prof. Otto Pettersson published a paper "on the Influence of Ice-Melting upon Oceanic Circulation"¹, which is repeatedly cited above. But as Pettersson's theories in several important respects bear upon the subjects discussed in the present paper, they should perhaps be somewhat more fully touched upon here. In a somewhat modified form Pettersson still upholds his old theory as to the great importance of ice-melting in the formation of ocean-currents.

Formerly² he was of the opinion that it was chiefly the buoyancy of the nearly fresh water, formed by the melting of ice, which produced the polar current between Iceland and Jan Mayen, whilst the cooling of the underlying waters was at the same time of some but less importance. But now, after the experiments of Mr. Sandström on the effect of ice-melting, he has obviously come to the conclusion that it is cooling which is of greatest importance; and this certainly seems to be more likely. But in one essential respect his standpoint is different now; he had previously only touched upon conditions obtaining in the sea between Iceland and Jan Mayen, but now he extends his theory to be available for all parts of the Ocean wherever ice occurs; even the North Polar Basin itself. He seems either to have overlooked the fact that the ice which melts must also once have been formed in the sea, or else he has misconceived the Polar ice as fresh-water ice from the Siberian rivers. It is of course true that river-ice carried into the sea, as well as glacial ice, cool the sea somewhat (as the heat disengaged during the

¹ Pettersson, *Geographical Journal*, London, vol. XXIV, 1904, pp. 285—333.

² Pettersson, *Öfversigt af Kongl. Vet.-Akad. Förhandlingar*. 1899, No. 3. Stockholm; *Ymer*, Stockholm, 1900, p. 157—189; *Pett. Mitt.* 1900, Heft III and IV.

freezing process was given to the land and atmosphere) but these small quantities of ice are of no importance compared with the enormous Polar ice-masses formed in the North Polar Basin itself, and the cooling thus produced, is naturally negligible compared with that caused by radiation from the surface of the Polar and Arctic Seas during the long winter.

On an earlier occasion¹ it was pointed out that it is the buoyancy of the layer, 200 metres thick, of diluted light water which, in connection with the wind, is of essential importance in the formation of the East Greenland and East Iceland Polar Current and not the thin surface layer of diluted water formed by the ice-melting. It is therefore not necessary to repeat these arguments here; there remains only to discuss Pettersson's theory in its new form. It may first be pointed out that he still overlooks the fact that the *Polar ice* floats in a layer of diluted Polar water of low salinity, 100 or 200 metres thick; and in the northern seas which he mentions, there is, according to the writer's knowledge, not a single place where this ice comes into direct contact with Atlantic water. Distinction has, however, to be made between Polar ice and the thinner ice, of much wider distribution, which is formed during the winter in the northern parts of the Norwegian Sea itself (*cf.* above p. 80). It is the latter kind of ice which has the wide extension eastwards mentioned by Pettersson, between Jan Mayen and Spitsbergen, and between Jan Mayen and Iceland, in the spring and early summer; and by the melting of this ice the same quantity of heat is of course consumed as was disengaged on its formation.

It was above (p. 78) pointed out that no appreciable quantity of heat can be conducted to the underside of the polar ice from the underlying warmer water², through the cold polar water with a temperature-minimum at 50 or 60 metres.

Pettersson also appears to have forgotten that, the Atlantic Current in its way from the Shetlands to Spitsbergen is cooled about 10° C. near the surface and at least 4 or 5° C. in the deeper layers *without any contact with ice* (and the amplitude between summer and winter-

¹ Oceanography of N. P. Basin. See also *Nyt Mag. for Naturvid.* vol. 39, 1901, p. 157.

² If there be such an effective conduction of heat through these water strata, as Pettersson is prone to believe, the temperature-minimum at 50 metres must have a cooling effect upon the overlying water-strata; and if the water at 50 metres be cooled down to freezing point by contact with the ice it must naturally cause a formation of ice in the overlying water strata with a lower salinity. A conduction of heat to the ice-floes from below, through this temperature-minimum is of course excluded.

temperatures is several degrees down to depths of many metres) whilst on the much longer way from Spitsbergen to the New Siberian Islands the water of the same current is cooled only 2°C. at the most.

And again, the formation of the enormous masses of ice over the deep North Polar Basin disengages a great quantity of heat, compared with which the amount of heat consumed in melting ice during the short summer-months is indeed very small. The observations during the "Fram" Expedition also prove that the heat consumed by this melting (which is chiefly limited to the upper surface of the ice) is derived directly from the sun and atmosphere, and not from the underlying seawater (see above p. 80). This is also to a very great extent the case in the East Greenland Polar Current north of Denmark Strait (*cf.* above p. 79)¹.

Pettersson also believes that this layer, 200 metres thick, of Polar water, covering the North Polar Basin (which is diluted by an intermixture between the water from Siberian (and American) rivers and the water carried into this Sea by the Atlantic Current) can only be formed by the melting of ice, and that therefore "the fresh water from the Siberian rivers is converted into ice by freezing before its admixture with the Atlantic water". He says that "it is necessary to admit this, because the intermingling of two water-layers of different salinity in a deep sea is an extremely slow process" (*loc. cit.* p. 321). Under these circumstances it is not clear how Pettersson thinks the layers of ordinary coast-water along the continental coasts can be formed without any formation or melting of ice. If he be correct, it is to be expected that during the summer the river water must float on the surface along the Siberian coast. But at only short distances outside the mouths of the Siberian rivers the surface water already has salinities of 10 and 20 ‰. Pettersson apparently believes that all ice in the North Polar Basin is formed in the shallow sea over the continental shelves near the coasts, and is afterwards melted during its drift across the deep North Polar Basin. If so, the thickest ice-floes met with during the drift of the "Fram"

¹ If the heat required for the melting of the ice were chiefly taken from the heat of the warm Atlantic undercurrent, as assumed by Pettersson, it would be unlikely that this melting would depend to any great extent on the season. For this undercurrent has always very nearly the same temperature, and there could not consequently be any great difference in the distribution of polar ice in summer and winter; whilst in seas like the Kara Sea, and the shallow Siberian Sea, there could hardly ever be any ice-melting because there is no warm undercurrent. But nevertheless there is actually a very great difference in the distribution of the ice between summer and winter as Pettersson himself points out.

ought to have been found near to the Siberian Coast. But the real state of things is the exact opposite, as is proved by the observations made during that expedition. Over the continental shelf north of Siberia the ice is comparatively thin; there is much open water during the summer and autumn, whilst the greatest quantity of ice as well as the thickest ice-floes are formed over the deep North Polar Basin. There is also much more melting of ice going on during the summer in the shallow sea north of Siberia, than there is over the deep Basin farther north.

Prof. Pettersson has two theories about the origin of bottom-water of the Norwegian Sea. On pp. 318—319, he assumes that the cold heavy water observed at Amundsen's Stations (and at Ryders Stations) comes from the North Polar Basin, forms "the deeper layers" of the East Greenland Polar Current and sinks "to the bottom of the Norwegian Sea". It was pointed out above that this theory is impossible, because no such water comes from the North Polar Basin with the East Greenland Polar Current, the deeper layers of which have no temperatures and no salinities similar to those of the cold bottom-water at Amundsen's Stations.

On p. 329 of the same paper Prof. Pettersson says that he has "calculated that part of the Atlantic under-current which mixes with the ice-water to be one-eighteenth, while the remaining seventeen-eightieths become cooled from contact with the ice and sink to the bottom, there to form the great bottom layer of cold water of only -1.0 to -1.4°C. " On the one hand Pettersson here repeats a mistake which the writer has already pointed out on several previous occasion. He like several other authors obviously still has the misconception that the upper layers of diluted cold water of the East Greenland Polar Current are due to the melting of ice, whilst the observations during the "Fram" Expedition have proved that the whole North Polar Basin is covered by a similar layer about 200 metres thick, on the surface of which the polar ice is formed. The East Greenland Polar Current is formed chiefly of the same waters from the North Polar Basin, having very similar salinities. A calculation like that of Pettersson's is therefore quite fallacious.

On the other hand Pettersson seems unaware that nowhere in the regions mentioned by him does the "Atlantic under-current", come into contact with the Polar ice, from which it is separated by the layer of diluted Polar water. This was fully mentioned above. But if in spite of all, it be assumed that cold bottom-water might be formed in this way by the melting of the ice, such water must be formed chiefly during the summer, while the melting of the ice is going on, and it must be

expected that this cold water will then approach nearest to the sea-surface, or at least to the under side of the ice; which is not the case. It has been pointed out above, that during the summer, while the ice is melting, the surface strata of the sea become warmer, and the upper limit of the cold bottom-water sinks towards greater depths; during the winter, however, while ice is being formed, the upper strata are cooled towards their minimum temperature, and the cold bottom-water approaches near the surface. It is thus seen that no cold bottom-water of the Norwegian Sea can under any circumstances be formed directly by cooling due to the melting of Polar ice, and only to a very small extent by the melting of Arctic ice, formed in the northern Norwegian Sea. If there were ice-bergs it might be a different thing, but ice-bergs of sufficient size only occur near to the Greenland coast, and their number is not sufficiently great, to make them of much importance in this connection.

Table I.

Surface Temperatures, Salinities, and Densities along Amundsen's Route, April—Sept. 1901.

Explanations of Table I.

1st Column. Date and Hour of Observation.

2nd Column. North Latitude (N) and Longitude East (E) or West (W) of Greenwich.

For 8 a. m. and 8 p. m., or where this has not been suitable, at the nearest hours, the Temperature of the Air as well as the Magnetic Direction and Velocity of the Wind are given. The first figure is the Temperature of the Air in degrees Centigrade. The letters, N, W, etc., indicate the Magnetic Direction of Wind, and the last figure its Velocity according to a Scale ranging between 0 (= calm) and 6 (= Hurricane), and where the figures consequently have a value double those of the Beaufort Scale.

3rd Column. Depth in Metres. An *asterisk* after the figure indicates that the water sample was taken by the Amundsen Water-Bottle while the ship was sailing. The Temperature was then taken by a thermometer inserted in the water-bottle when it came on deck.

The surface water for the other observations was taken with an ordinary bucket.

4th Column. Temperature of the water *in situ*, in Degrees Centigrade. The thermometer No. 638 was used for most observations, it had a correction of 0.0° C. (see p. 7). In some few cases the thermometers No. 35 and 39 were used. The latter had no correction at zero and the former a zero correction of -0.05° C.

5th Column. Salinity (‰) derived by M. Knudsen's Tables from permillage of Chlorine, determined by Titration (Mohr). Some water-samples taken with the Amundsen Glass Water-Bottle on cold days in April and May, 1901, give absurd values of Salinity. The reason is obviously that ice has been formed on the water-bottle (see above p. 7).

6th Column. Density (σ_t) of Sea-Water derived by Knudsen's Tables from Salinity and Temperature.

Footnotes. The footnotes give the colour of the sea. Ice-sludge and "pancake-ice" means generally that new ice is being formed on the sea-surface. When the ice-crust is broken by the wave-movement it is broken into rounded disks of the size of pancakes, or into still smaller pieces forming by the friction against each other an ice-sludge.

Table I. Surface Observations.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Temperature	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Temperature	Salinity ‰	σ_t
April 1901		M.	°C.	‰		April 1901		M.	°C.	‰	
2 p. m.	Hjelmesø in ESE, 8 miles off	0*	3.2	34.41	27.42 ¹	25, 8:20 -	31° W 1	0*	1.30	34.87	27.94 ⁴
2:10 -		5*	3.1	34.46	27.47 ¹	- 8:30 -		5*	1.30	34.88	27.95 ⁴
2:20 -		10*	3.0	34.45	27.44 ¹	- 11 -		0	1.1	34.90	27.98 ⁴
8:10 -	1.2° E 1	0*	3.3	34.46	27.45 ²	- 12 noon	71°3' N 42°00' E				
8:20 -	71°22' N 25° 8' E	5*	3.3	34.49	27.46 ²	- 2:10 p. m.		0*	0.34	34.72	27.89 ⁴
8:30 -		10*	3.3	34.51	27.47 ²	- 2:20 -		5*	0.41	34.71	27.88 ⁴
2:15 a. m.	71°19' N 25°24' E	0*	2.84		2	- 2:30 -		10*	0.40	34.70	27.87 ⁴
2:25 -		5*	2.84	34.45	27.48 ²	- 4:10 -	70°55' N 41° 0' E				
2:35 -		10*	2.75	34.43	27.48 ²	- 8:10 -		0*		34.70	
8:15 -	2.1° ESE 1	0*	3.40	34.46	27.44 ²	- 8:20 -	1° NW 4	5*		34.68	
8:25 -	North Cape in WbS, 3 miles off	5*	3.30	34.49	27.46 ²	- 8:30 -		10*		34.59	
8:35 -		10*	3.41	34.49	27.46 ²	26, 2:20 a. m.		0*	-0.40	34.72	27.92 ⁴
12 noon	71°18' N 26°50' E					- 2:30 -		5*	-0.40	34.68	27.89 ⁴
2:15 p. m.		0*	3.26	34.46	27.45 ³	- 2:40 -	-0.1° N 0.5	10*	-0.40	34.71	27.91 ⁴
2:25 -	71°18' N 27°00' E	5*	3.30	34.51	27.47 ³	- 8:10 -	70°25' N 42°24' E	0	-0.3	34.70	27.91 ⁴
2:35 -		10*	3.02	34.53	27.52 ³	- 8:20 -		0*		34.74	
8:45 -	71°37' N 28°15' E				3	- 12 noon	70°25' N 42°24' E	5*		34.69	
9	1.1° S 2.5	5*		34.58	3	27, 2 a. m.		0*	-1.3		
9:15 -		10*		34.61	3	- 2 -		5*	-1.3	34.71	27.95 ⁴
12 midn.		0	2.4	34.57	27.61 ³	- 2 -		10*	-1.3	34.69	27.93 ⁴
2 a. m.		0	2.4	34.57	27.61 ³	- 2 -	2.0° W 2.0	0*	-0.7	34.72	27.93 ⁴
4 -		0	2.0	34.58	27.65 ³	- 8 -		5*	-0.7	34.74	27.95 ⁴
6 -		0	2.0	34.66	27.72 ³	- 8 -		10*	-0.7	34.69	27.90 ⁴
8 -	1.0° S 3	0	2.2	34.72	27.75 ³	- 12 noon	70°42' N 42°22' E				
10 -		0	2.4	34.79	27.80 ³	- 2 p. m.		0*	-0.1	34.73	27.92 ⁴
12 noon	71°45' N 33°50' E	0	2.3	34.79	27.81 ⁴	- 2 -	-0.7° NW 4	5*	-0.1	34.77	27.95 ⁴
2:10 p. m.		0*	2.39	34.79	27.80 ⁴	- 8 -		0*	0.4		
2:20 -		5*	2.40	34.80	27.81 ⁴	- 8 -		5*	0.4	34.83	27.97 ⁴
4 -		0	2.3	34.87	27.87 ⁴	28, 2 a. m.		0*	0.4	34.87	28.00 ⁴
6 -		0	2.3	34.87	27.87 ⁴	- 5 -		0	0.1	34.89	28.05 ⁴
8:20 -	3.2° SW 1	0*	1.90	34.87	27.90 ⁴	- 8 -		0	0.1	34.81	27.97 ⁴
8:30 -		5*	1.92	34.86	27.89 ⁴	- 12 noon	71°33' N 45°30' E	0	-0.2	34.74	27.93 ⁴
8:40 -		10*	1.90	34.85	27.89 ⁴	- 12 midn.	-3.8° NNE 2.5	0	-1.0	34.70	27.94 ⁴
11 -		0	1.8	34.84	27.88 ⁴	29, 2 a. m.		0	-0.8	34.64	27.87 ⁵
2:10 a. m.		0*	1.55	34.85	27.92 ⁴	- 4 -		0	-1.9	34.49	27.78 ⁵
2:20 -		5*	1.61	34.87	27.93 ⁴	- 6 -		0	-2.0	34.44	27.74 ⁵
5 -		0	1.5	34.85	27.92 ⁴	- 8 -	-0.6° N 3	0	-2.0	[33.45] ²	5

¹ Sea blue. ² Sea dark blue. ³ Sea somewhat lighter blue. ⁴ Sea gray. ⁵ Formation of ice-sludge on sea surface gray.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
April 1901		M.	° C.	‰		May 1901		M.	° C.	‰	
29, 10 a. m.		0	-1.9	[32.87] ⁵	26.47 ¹	2, 8 p. m.	-6.0° E 0.5	0	-1.4	34.61	27.88
- 12 noon	71°34' N 47°30' E	0	-2.0	34.78	28.03 ¹	- 10 -		0	-1.8	34.51	27.84
- 2 p. m.		0	-1.9	34.60	27.87 ¹	- 12 midn.		0	-1.8	34.51	27.84
- 4 -		0	-1.7	34.54	27.83 ¹	3, 2 a. m.		0	-1.8	34.61	27.88
- 4 -		5*	-1.7			- 4 -		0	-1.8	34.72	27.97
- 6 -		0	-1.9	34.70	27.96 ¹	- 6 -		0	-1.8	34.61	27.88
- 8 -	-9.0° N 2	0	-1.9	34.78	28.03 ¹	- 8 -	-7.0° SSE 1	0	-1.9	34.61	27.88
- 10 -		0	-1.9	34.64	27.90 ¹	- 9 -		0	-1.7	34.08	27.44
- 12 midn.		0	-1.8	34.44	27.74 ¹	- 9 -		5*	-1.8	34.12	27.48
30, 2 a. m.		0*	-1.8	34.48	27.77 ²	- 10 -		0	-1.9	34.63	27.90
- 2 -		5*	-1.8	34.56	27.85 ²	- 12 noon	70°20' N 48°30' E	0	-1.7	34.43	27.74
- 4 -		0	-1.9	34.44	27.75 ²	- 12 -		5*	-1.8	34.69	27.94
- 6 -		0	-1.9	34.44	27.75 ²	- 2 p. m.		0	-1.7	34.32	27.64
- 8 -	-4.9° W 1.5	0*	-1.8	34.52	27.81 ²	- 2 -		5*	-1.8	[35.36]? ⁹	
- 8 -		5*	-1.8	34.81	28.05 ²	- 4 -		0	-2.0	34.64	27.97
- 10 -		0	-1.9	34.34	27.67 ²	- 6 -		0	-1.9	34.48	27.78
- 12 noon	71°10' N 47°34' E	0	-1.8	34.50	27.79 ²	- 6 -		5*	-1.8	[35.36]? ⁹	
- 4 p. m.		0	-1.8	34.44	27.74 ²	- 8 -	-8.5° ENE 2	0	-2.0	34.68	27.94
- 6 -		0	-1.7	34.41	27.71 ²	- 10 -		0	-1.8	34.61	27.88
- 8 -	-1.7° SW 3.5	0	-1.6	34.37	27.65 ³	- 10 -		5*	-1.8	[35.35]? ⁹	
- 8 -		5*	-1.8	[35.26]? ⁹		- 10 -		10*		[Above 36.00] ⁹	
- 10 -		0	-1.7	34.41	27.71 ³	- 12 midn.		0	-2.0	34.66	27.94
- 12 midn.		0	-1.5	34.63	27.89 ³	4, 2 a. m.		0	-1.8	34.61	27.88
May 1901						- 2 -		5*	-1.8	[35.32] ⁵	
1, 2 a. m.		0	-1.3	34.64	27.90 ³	- 4 -		0	-2.0	32.82 ⁵	
- 2 -		5*	-1.5	[34.90]? ⁹		- 6 -		0	-1.9	32.89 ⁵	
- 4 -		0	-1.4	34.32	27.63 ³	- 6 -		5*	-1.8	[35.71]? ⁹	
- 6 -		0	-1.5	34.64	27.90 ³	- 8 -	-1.8° SSE 2	10*	-1.9	[36.26]? ⁹	
- 8 -	-1.5° WNW 3	0	-1.3	34.60	27.86 ⁴	- 10 -		0	-1.9	34.44	27.78
- 10 -		0	-1.1	34.54	27.81 ⁴	- 10 -		0	-1.7	34.54	27.88
- 12 noon	71°17' N 46°30' E	0	-1.3	34.73	27.97 ⁴	- 12 noon	69°56' N 47°30' E	0	-1.9	34.53	27.88
- 2 p. m.		0	-1.2	34.61	27.87 ⁴	- 2 p. m.		0	-1.7	34.53	27.88
- 4 -		0	-1.2	34.79	28.01 ⁴	- 2 -		5*	-1.7	34.50	27.78
- 6 -		0	-1.2	34.58	27.84 ⁴	- 2 -		10*	-1.7	34.47	27.77
- 8 -	-6.0° N 1	0	-1.2	34.70	27.94 ⁴	- 4 -		0	-1.9	34.46	27.76
- 10 -		0	-0.3	34.80	27.99 ⁴	- 6 -	69°40' N 47°36' E	0	-1.9	34.57	27.88
- 10 -		5*	-0.4	34.81	28.00 ⁴	- 8 -	-5.2° ESE 2	0	-1.9	34.53	27.88
- 10 -		10*	-0.4	34.74	27.94 ⁴	- 10 -		0		34.54	
- 12 midn.		0	-0.1	34.83	28.00 ⁴	- 10 -		5*		34.63	
2, 2 a. m.		0	-0.1	34.83	28.00 ⁴	- 10 -		10*			
- 4 -		0	-0.1	34.90	28.06 ⁴	- 12 midn.		0		34.56	
- 6 -		0	-0.1	34.88	28.04 ⁴	5, 2 a. m.		0		34.37	
- 8 -	-6.5° N 0.5	0	0.2	34.81	28.00 ⁴	- 2 -		5*		34.76	
- 10 -		0	0.2	34.81	28.00 ⁴	- 4 -		0		[33.97] ⁵	
- 10 -		5*		34.83		- 6 -		0	-1.9	[33.40] ⁵	
- 12 noon	71°3'12" N 46°00' E	0	-0.3	34.75	27.94 ⁴	- 8 -	-9.9° ENE 2	0	-1.8	34.79	28.00
- 2 p. m.		0	-0.3	34.75	27.94 ⁴	- 10 -		0	-1.8	34.47	27.77
- 2 -		5*	-0.4	34.74	27.94	- 12 noon	69°40' N 47°36' E	0	-1.8	34.72	27.97
- 6 -	71°4' N 45°38' E	0	-0.35	34.74	27.94 ⁴	- 1 p. m.		0	-1.8		
						- 1 -		5*	-1.8	[35.28]? ⁹	28.4

¹ Formation of ice-sludge on the surface. Sea gray. ² No formation of ice-sludge on the surface. gray. ³ Sea grayish brown. ⁴ Sea gray. ⁵ Small ice-needles floating in the water may have come into sample. ⁶ Through ice-sludge and "pancake-ice". ⁷ Through an open lane in the ice. ⁸ Through open ice. As the thermometer indicated -2.0° C. and even -2.4° C. it was considered untrustworthy and the readings were not recorded. ⁹ Through ice-sludge and pancake-ice. Sea gray. ¹⁰ Through a belt of dense pancake ice. ¹¹ Lying in tight ice.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
May 1901		M.	° C.	‰		May 1901		M.	° C.	‰	
5, 1 p. m.		10*	-1.8	34.60	27.87 ¹	8, 6 p. m.		0	-1.8	34.49	27.78 ⁵
- 4 -		0	-1.8	34.58	27.86 ¹	- 6 -		5*	-1.9	[34.97] ²	[28.19]
- 6 -	70°4' N	0	-1.8			- 8 -		10*	-1.9	34.60 ²	27.87
- 6 -	48°26' E					- 10 -	-2.7° NW 3	0	-1.8	[35.07] ²	[28.25]
- 8 -	-8.5° ENE 2	5*	-1.8	34.50	27.79 ²	- 12 -		0	-1.8	34.48	27.77 ⁶
- 11 -		0	-1.8	34.50	27.79 ²	- 12 midn.		0	-1.8	34.50	27.79 ⁶
- 11 -		0	-1.8	34.67	27.93 ²	- 12 -		5*	-1.9		
- 11 -		5*	-1.8	[34.88]	[28.10] ²	- 12 -		10*	-1.9	34.61	27.89
- 12 midn.		10*	-1.8	[35.05]	[28.23] ²	9, 2 a. m.		0	-1.8	34.47	27.77 ⁶
6, 2 a. m.		0	-1.8	34.67	27.93 ²	- 4 -		0	-1.8		
- 2 -		0	-1.8	34.66	27.92 ²	- 6 -		0	-1.8	34.41	27.71 ⁶
- 4 -		5*	-1.8	[35.36] ²		- 8 -		5*	-1.9	34.78 ²	28.02 ²
- 6 -		0	-1.8	34.63	27.68 ²	- 10 -	-1.2° NNW 2	0	-1.8	34.42	27.72 ⁶
- 8 -		0	-1.9	[32.78] ²		- 12 noon	69°32' N	0	-1.7	34.40	27.71 ⁶
- 8 -		0	-1.9	34.65	27.91 ²	- 12 -	45°39' E	5*	-1.5		
- 10 -	-7.2° E 3	5*	-1.9	[36.9] ²		- 12 -		10*	-1.5	34.43	27.73
- 10 -		0	-1.9	34.70	27.97 ²	- 2 p. m.	-0.4° WbN 0.5	0	-1.6	34.40	27.70 ⁷
- 12 noon	70°00' N	0	-1.8	34.79	28.03 ²	- 4 -	69°32' N	0	-1.4	34.42	27.71 ⁷
2 p. m.	48°20' E	0	-1.8	34.70	27.96 ²	- 6 -	45°33' E	0	-1.5	34.40	27.70 ⁸
- 2 -		5*	-1.8	[35.93] ²		- 10 -	69°32' N	0	-1.6	34.42	27.71 ⁸
- 4 -		0	-1.9	[32.95] ²		- 12 midn.	45°33' E	0	-1.7	34.40	27.71 ⁸
- 6 -		0	-1.9	34.73	27.98 ²	10, 2 a. m.		0	-1.7	34.42	27.72 ⁸
- 8 -	-6.8° ENE 2.5	0	-1.9	34.62	27.90 ²	- 4 -		0	-1.7	34.42	27.72 ⁸
- 8 -		5*	-1.8	34.39 ²	27.70 ²	- 6 -		5*	-1.8	34.44	27.74
- 10 -	69°50' N	0	-1.8	34.62	27.89 ²	- 8 -	-0.5° SSW 1	10*	-1.8	34.41	27.71
- 10 -	48°10' E	5*	-1.8	34.65	27.91	- 10 -		0	-1.7	34.41	27.71 ⁸
- 10 -		10*	-1.8	34.61	27.88	- 12 noon	69°15' N	0	-1.4	34.36	27.67 ⁸
- 12 midn.		0	-1.8	34.62	27.89 ²	- 12 -	45°20' E	5*	-1.3	34.47	27.76
- 12 -		5*	-1.8	34.83	28.06	- 12 -		10*	-1.4	34.46	27.75
7, 2 a. m.		0	-1.8	34.58	27.86 ³	- 2 p. m.		0	-1.3	34.37	27.68 ⁸
- 2 -		5*	-1.8	[35.27] ²		- 4 -		0	-1.3	34.27	27.59 ⁹
- 4 -		0	-1.8	34.52	27.81 ³	- 6 -	69°12' N	0	-1.2	34.38	27.68 ¹⁰
- 6 -	-4.5° N 4	0	-1.9	34.14	27.51 ³	- 8 -	45° 0' E	5*	-1.4	34.34	27.66
- 8 -		0	-1.9	34.53	27.82 ³	- 10 -	69°10' N	0	-1.4	34.43	27.73 ¹¹
- 10 -		0	-1.7	34.42	27.72 ³	- 12 midn.	44°50' E	0	-1.4	34.38	27.69 ¹¹
- 12 noon	69°40' N					- 12 -	0.3° WSW 1	0	-1.8	34.41	27.71 ¹¹
	47°55' E					- 12 -		5*	-1.7	34.48	27.77
9 p. m.	69°35' N	Lying in tight "bay-ice" (i.e. newly formed ice). Came out into an open lane.				11, 2 a. m.		0	-1.6	34.38	27.69 ¹¹
	47°35' E	0	-1.8	34.41	27.71 ¹¹	- 4 -		0	-1.4	34.23	27.57 ¹²
8, 1 a. m.		0	-1.8	34.42	27.72 ¹¹	- 6 -		0	-1.3	34.21	27.53 ¹³
- 4 -		0	-1.8			- 8 -		5*	-1.4	34.21	27.54
- 6 -		0	-1.8			- 10 -	2.6° WSW 1.5	10*	-1.2	34.27	27.59
- 8 -	-3.1° NW 3	0	-1.8	34.40	27.71 ¹¹	- 11 -		0	-1.2	34.29	27.60 ¹³
- 8 -		5*	-1.9	34.70	27.96	- 11 -		0	-1.2	34.24	27.56 ¹³
- 8 -		10*	-1.9	34.90 ²	28.11 ²	- 11 -		0	-1.6	34.21	27.57 ¹³
- 10 -		0	-1.8	34.57	27.85 ⁴	- 11 -		5*	-1.4	34.23	27.57
- 12 noon	69°15' N	0	-1.8	34.44	27.74 ⁴	- 11 -		10*	-1.5	34.24	27.57
- 12 -	44°51' E	5*	-1.9	34.61 ²	27.89 ²						
- 12 -		10*	-1.9	34.49	27.78 ⁴						
- 2 p. m.	69°10' N	0	-1.8	34.42	27.72 ¹¹						
- 4 -	44°52' E	0	-1.8	34.47	27.77 ⁴						

¹ Lying in tight ice. ² Through ice-sludge and pancake-ice. Sea gray. ³ In open water. Sea brownish gray. ⁴ Sea gray. ⁵ In an open lane. Sea gray. ⁶ Sea somewhat greener. ⁷ Sea light green. ⁸ In a bay on the ice. Indication of thin ice crust being formed. ⁹ Came out of the bay in the ice. ¹⁰ Tackling along the margin of the ice. ¹¹ Sea grayish green. ¹² Along the ice-edge. ¹³ The sea has the colour of brackish water with a greenish tinge.

Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
May 1901		M.	° C.	‰		May 1901		M.	° C.	‰	
11, 12 noon	69°1' N 44°28' E	0	-1.2	34.23	27.56 ¹	14, 12 noon	69°43' N 46°20' E	0	-0.9	34.32	27.62
- 1 p. m.		0	-1.4	34.22	27.55 ¹	- 12 -		5*	-0.9	34.32	27.62
- 2 -		0	-1.4	34.11	27.47 ¹	- 12 -		10*	-0.8	34.33	27.62 ⁴
- 2 -		5*	-1.4	34.17	27.52	- 2 p. m.		0	-0.8	34.25	27.52 ⁴
- 3 -		0	-1.4	34.10	27.46 ¹	- 4 -		0	-0.5	34.33	27.60 ⁴
- 4 -		0	-1.4	34.05	27.42 ¹	- 6 -		0	-0.5	34.32	27.60 ⁴
- 6 -		0	-1.4	34.16	27.51 ¹	- 8 -	-0.5 SW 1.5	0	-0.4	34.27	27.60 ⁵
- 6 -		5*	-1.4	34.22	27.55	- 10 -		0	-1.0	34.23	27.55 ⁵
- 6 -		10*	-1.4	34.18	27.53	- 12 midn.		0	-1.2	34.27	27.59 ⁵
- 8 -	0.8° WSW 0.5	0	-1.4	34.19	27.53 ¹	15, 2 a. m.	69°55' N 46°45' E	0	-1.4	34.37	27.68 ⁵
- 10 -		0	-1.3	34.17	27.51 ¹	- 2 -		5*	-1.3	34.35	27.66
- 12 midn.		0	-1.5	34.14	27.50 ¹	- 2 -		10*	-1.3	34.36	27.66
- 12 -		5*	-1.7	34.20	27.55	- 4 -		0	-1.5	34.37	27.68 ⁴
- 12 -		10*	-1.7	34.22	27.56	- 6 -		0	-1.5	34.38	27.69 ⁴
12, 2 a. m.		0	-1.3	34.17	27.51 ¹	- 8 -	-1.1° SSW 1	0	-1.5	34.36	27.67 ⁴
- 4 -		0	-1.4	34.20	27.54 ¹	- 8 -		5*	-1.5	34.41	27.71
- 6 -		0	-1.4	34.17	27.55 ¹	- 8 -		10*	-1.5		
- 6 -		5*	-1.5	34.21	27.54	- 10 -		0	-1.3	34.33	27.63 ⁴
- 6 -		10*	-1.5	34.18	27.53	- 12 noon	70°42' N 47°20' E	0	-1.3	34.41	27.70 ⁴
- 8 -	0.5° S 0.5	0	-1.3	34.22	27.54 ¹	- 12 -		5*	-1.2	34.41	27.70
- 10 -		0	-1.2	34.32	27.63 ¹	- 2 p. m.		0	-1.2	34.37	27.67 ⁴
- 12 noon	69°12' N 45°27' E	0	-1.5	34.32	27.64 ¹	- 4 -		0	-1.4	34.35	27.66 ⁴
- 12 -		5*	-1.5	34.39	27.70	- 6 -		0	-1.4	34.36	27.67 ⁴
- 12 -		10*	-1.5	34.75	27.99	- 6 -		5*	-1.5	34.42	27.71
- 2 p. m.	69°16' N 45°28' E	0	-1.0	34.36	27.65 ²	- 6 -		10*	-1.5	34.35	27.67
- 4 -		0	-1.1	34.35	27.65 ²	- 8 -	1.0° S 2	0	-1.4	34.37	27.68
- 6 -		0	-1.1	34.39	27.68 ²	- 10 -	70°38' N 47°10' E	0	-1.3	34.39	27.69 ⁴
- 6 -		5*	-1.1	34.42	27.70	- 12 midn.		0	-1.3	34.39	27.69 ⁴
- 8 -	0.5 W 0.5	0	-1.2	34.39	27.69 ²	- 12 -		5*	-1.3	34.39	27.69
- 10 -		0	-1.2	34.37	27.67 ²	- 12 -		0	-1.7	34.29	27.62 ⁴
- 12 midn.	69°40' N 46°30' E	0	-1.2	34.33	27.63 ²	16, 2 a. m.		0	-1.6	34.34	27.66 ⁴
- 12 -		5*	-1.2	34.33	27.63	- 6 -		0	-1.4	34.34	27.66 ⁴
- 12 -		10*	-1.2	34.66	27.90	- 6 -		5*	-1.4	34.38	27.69
13, 2 a. m.	69°40' N 46°30' E	0	-1.2			- 6 -		10*	-1.4	34.38	27.69
- 4 -		0	-1.2	34.32	27.63 ²	- 8 -	0° N 0.5	0	-1.4	34.34	27.66 ⁴
- 6 -		0	-1.0	34.37	27.66 ²	- 10 -	69°40' N 46°20' E	0	-1.2	34.40	27.69 ⁴
- 6 -		5*	-1.0	34.40	27.68	- 2 p. m.		0	-1.0	34.39	27.68 ⁴
- 8 -	1.0 SSW 0.5	0	-1.0	34.36	27.65 ²	- 4 -		0	-1.1	34.37	27.67 ⁴
- 10 -		0	-0.8	34.37	27.65 ²	- 6 -	69°40' N 46°20' E	0	-1.2	34.33	27.63 ⁴
- 12 noon	69°55' N 46°20' E	0	-0.8	34.37	27.66	- 6 -		5*	-1.2	34.33	27.63 ⁴
- 2 p. m.		0	-1.4	34.27	27.60 ³	- 8 -	-0.1° NE 0.5	0	-1.5	34.33	27.64 ⁴
- 4 -	70° 0' N 46°20' E	0	-1.5	34.32	27.64 ³	- 10 -		0	-1.2	34.28	27.60 ⁴
- 6 -		0	-1.5	34.27	27.60 ³	- 12 midn.		0	-1.2	34.33	27.63 ⁴
- 8 -		0	-1.4	34.50	27.78 ³	- 12 -	69°23' N 46°20' E	5*	-1.2	34.33	27.63
- 10 -	-0.2° NW 2.5	0	-1.2	34.34	27.65 ³	17, 2 a. m.		0	-1.1	34.34	27.68 ⁴
14, 2 a. m.		0	-1.3	34.32	27.63 ⁴	- 2 -		5*	-1.1	34.35	27.65
- 4 -		0	-1.3	34.33	27.56 ⁴	- 4 -		0	-1.1	34.34	27.68 ⁴
- 6 -		0	-1.3	34.30	27.61 ⁴	- 4 -		5*	-1.2	34.35	27.66
- 8 -	-0.1° NW 0.5	0	-1.2	34.25	27.57 ⁴	- 6 -		0	-1.1	34.34	27.68 ⁴
- 8 -		5*	-1.2	34.31	27.62 ⁴	- 6 -		5*	-1.3	34.33	27.63
- 8 -		10*	-1.2	34.33	27.63 ⁴	- 8 -	-0.3° NE 3	0	-1.2	34.40	27.69 ⁴
- 10 -		0	-0.9	34.29	27.59 ⁴	- 8 -		5*	-1.3	34.36	27.66

¹ The sea has the colour of brackish water with a greenish tinge. ² Sea dark blue. ³ Sea gray.
⁴ Along the ice-edge. Sea gray. ⁵ In a bay in the ice.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
May 1901		M.	° C.	‰		May 1901		M.	° C.	‰	
7, 8 a. m.		10*	-1.3	34.38	27.68	19, 8 a. m.	-1.0° E 3	0	-1.2	34.44	27.73 ³
10 -		0	-1.4	34.38	27.69 ¹	- 8 -		5*	-1.2	34.45	27.73
10 -		5*	-1.3	34.43	27.72	- 10 -		0	-1.0	34.41	27.69 ³
12 noon	69°48' N 46°25' E	0	-1.3	34.38	27.68 ¹	- 10 -		5*	-1.0	34.43	27.71
12 -		5*	-1.2	34.37	27.67	- 12 noon	70°20' N 46°16' E	0	-1.0	34.49	27.75 ³
12 -		10*	-1.2	34.35	27.66	- 12 -		5*	-1.0	34.47	27.74
2 p. m.		0	-1.3	34.38	27.68 ¹	- 12 -		10*	-1.0	34.48	27.75
2 -		5*	-1.2	34.36	27.66	- 2 p. m.		0	-1.0	34.54	27.81 ³
4 -		0	-1.2	34.37	27.67 ¹	- 2 -		5*	-0.9	34.54	27.80
4 -		5*	-1.3	33.39	27.69	- 4 -		0	-1.0	34.57	27.83 ³
6 -		0	-1.3	34.36	27.67 ¹	- 4 -		5*	-1.0	34.56	27.82
6 -		5*	-1.3	34.36	27.67	- 6 -		0	-1.0	34.57	27.83 ³
6 -		10*	-1.3	34.37	27.67	- 6 -		5*	-1.0	34.60	27.85
8 -	-1.0 NE 3	0	-1.3	34.41	27.70 ¹	- 6 -		10*	-1.0	34.58	27.84
8 -		5*	-1.4	34.29	27.61	- 8 -		0	-1.1	34.56	27.82 ³
10 -		0	-1.3	34.39	27.69 ¹	- 8 -	1.0° S 2	5*	-1.0	34.57	27.83
10 -		5*	-1.3	34.43	27.72	- 10 -		0	-1.1	34.59	27.85 ³
12 midn.	69°50' N 46°27' E	0	-1.3	34.36	27.67 ¹	- 10 -		5*	-1.0	34.55	27.71
12 -		5*	-1.3	34.34	27.65	- 12 midn.	70°21' N 46°16' E	0	-1.2	34.57	27.83 ³
12 -		10*	-1.3	34.33	27.63	- 12 -		5*	-1.1	34.52	27.79
8, 2 a. m.		0	-1.3	34.40	27.69 ¹	- 12 -		10*	-1.1	34.54	27.81
2 -		5*	-1.3	34.36	27.67	20, 2 a. m.		0	-1.1	34.55	27.71 ³
4 -		0	-1.3	34.35	27.65 ²	- 2 -		5*	-1.1	34.59	27.85
4 -		5*	-1.4	34.36	27.67	- 4 -		0	-1.1	34.60	27.85 ³
4 -		10*	-1.4	34.35	27.66	- 4 -		5*	-1.2	34.60	27.85
6 -		0	-1.3	34.39	27.69 ²	- 6 -		0	-1.1	34.61	27.87 ³
6 -		5*	-1.3	34.37	27.67	- 6 -		5*	-1.2	34.59	27.85
8 -	-1.2° NNE 1	0	-1.3	34.35	27.65 ²	- 6 -		10*	-1.2	34.60	27.85
8 -		5*	-1.4	34.34	27.66	- 8 -	0.9 SW 1	0	-1.1	34.52	27.79 ³
10 -		0	-1.0	34.34	27.65 ²	- 8 -	70°00' N 42°45' E	5*	-1.2	34.58	27.84
10 -		5*	-1.0	34.34	27.65	- 1 p. m.	70°4' N 42°45' E	0	-1.2	34.50	27.77 ³
12 noon	69°41' N 45°49' E	0	-0.9	34.30	27.60 ²	- 4 -		0	-1.1	34.53	27.80 ⁴
12 -		5*	-1.0	34.31	27.61	- 4 -		5*	-1.1	34.55	27.71 ⁴
12 -		10*	-1.1	34.29	27.60	- 6 -		0	-0.8	34.67	27.90 ⁴
2 p. m.		0	-0.8	34.27	27.58 ²	- 6 -		5*	-1.0	34.65	27.89
2 -		5*	-0.8	34.29	27.59	- 6 -		10*	-1.0	34.63	27.89
4 -		0	-0.7	34.20	27.51 ²	- 6 -		0	-0.8	34.70	27.93 ⁴
4 -		5*	-0.7	34.28	27.58	- 8 -	-0.2° WSW 2.5	5*	-0.7	34.70	27.92
6 -	69°41' N 45°59' E	0	-0.8	34.31	27.61 ²	- 8 -		0	-0.7	34.47	27.73 ⁴
6 -		5*	-1.0	34.27	27.58	- 10 -		5*	-0.7	34.49	27.74
8 -		0	-0.6	34.36	27.64 ²	- 10 -		0	-0.7	34.51	27.76 ⁴
8 -	-0.6 ENE 2	5*	-0.6	34.33	27.61	- 12 midn.	70°15' N 42°49' E	0	-0.7	34.51	27.76 ⁴
10 -		0	-0.8	34.32	27.61 ²	- 12 -		5*	-0.6	34.50	27.75
10 -		5*	-0.9	34.29	27.59	21, 2 a. m.		0	-1.0	34.46	27.73 ⁴
12 midn.	70°11' N 46°12' E	0	-0.9	34.41	27.69 ³	- 2 -		5*	-1.0	34.43	27.71
12 -		5*	-1.0	34.43	27.71	- 4 -		0	-1.0	34.44	27.72 ⁴
2 a. m.		0	-1.1	34.47	27.75 ³	- 4 -		5*	-1.3	34.44	27.73
2 -		5*	-1.2	34.46	27.74	- 6 -		0	-1.0	34.48	27.75 ⁴
2 -		10*	-1.2	34.43	27.72	- 6 -		5*	-1.3	34.48	27.76
4 -		0	-1.0	34.43	27.71 ³	- 8 -	-1.0° WNW 3	0	-1.0	34.49	27.76 ⁴
4 -		5*	-1.2	34.48	27.76	- 8 -		5*	-1.3	34.49	27.77
6 -		0	-1.1	34.43	27.72 ³	- 10 -		0	-1.4	34.46	27.75 ⁴
6 -		5*	-1.2	34.47	27.75	- 10 -		5*	-1.5	34.44	27.74
6 -		10*	-1.3	34.44	27.73	- 12 noon	70°30' N 42°55' E	0	-1.3	34.55	27.82 ⁴

¹ Along the ice-edge. Sea gray. ² Through slack ice. Sea grayish brown. ³ Along the ice-edge. Sea grayish brown. ⁴ In open sea. Sea gray.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
May 1901						May 1901					
21, 12 noon		M.	° C.	‰		23, 4 p. m.		M.	° C.	‰	
- 2 p. m.		5*	-1.5	34.48	27.77	- 6 -		5*	-1.9	34.61	27.89
- 2 -		0	-1.4	34.48	27.76 ¹	- 6 -		0	-1.9	34.53	27.82 ²
- 4 -		5*	-1.6	34.48	27.77	- 6 -		5*	-1.9	34.57	27.85
- 4 -		0	-1.4	34.47	27.76 ¹	- 6 -		10*	-1.9	34.62	27.90
- 6 -		5*	-1.5	34.49	27.77	- 8 -	-4.5° NW 2	0	-1.9	34.43	27.74 ³
- 6 -		0	-1.5	34.49	27.77 ¹	- 8 -		5*	-1.9	[34.95]?	[28.16]
- 8 -		5*	-1.6	34.49	27.77	- 10 -		0	-1.9	34.61	27.89 ²
- 8 -	-1.1° WNW 2	0	-1.5	34.55	27.83 ¹	- 10 -		5*		[35.13]?	
- 8 -		5*	-1.6	34.51	27.79	- 12 midn.	71°18' N 43°58' E	0	-1.8	34.66	27.91 ²
- 10 -		0	-1.4	34.49	27.77 ¹	24, 2 a. m.		0	-1.8	34.67	27.93 ²
- 10 -		5*	-1.6	34.47	27.76	- 2 -		5*	-1.8	34.61	27.89
- 12 midn.	70°48' N 43° 1' E	0	-1.3	34.53	27.81 ¹	- 2 -		10*	-1.8	34.59	27.86
- 12 -		5*	-1.4			- 4 -		0	-1.8	34.69	27.94 ³
- 12 -		10*	-1.5	34.52	27.80	- 4 -		5*	-1.7	34.66	27.82
22, 2 a. m.		0	-1.3	34.55	27.82 ¹	- 6 -		0	-1.8	34.70	27.96 ³
- 2 -		5*	-1.4	34.56	27.83	- 8 -	71°19' N 43°56' E	0	-1.7	34.79	28.03 ³
- 4 -		0	-1.2	34.55	27.82 ¹	- 8 -	-4.2° NW 1	5*	-1.7	[35.18]?	
- 4 -		5*	-1.3	34.56	27.83	- 8 -		10*	-1.7	34.88	28.10
- 6 -		0	-1.5	34.68	27.93 ¹	- 10 -		0	-1.8	34.61	27.89 ³
- 6 -	-1.0° S 2.5	5*	-1.5	34.66	27.91	- 10 -		5*	-1.9	[34.99]?	[28.19]
- 8 -		0	-1.5	34.65	27.90 ¹	- 12 noon	71°20' N 43°52' E	0	-1.8	34.56	27.84 ³
- 8 -		5*	-1.5	34.60	27.86	- 12 -		5*		[35.02]?	
- 10 -		0	-1.8	34.51	27.80 ²	- 2 p. m.		0	-1.7	34.55	27.83 ³
- 10 -		5*	-1.7	34.52	27.81	- 2 -		5*	-1.8	34.60	27.87
- 12 noon	71° 2' N 44°15' E	0	-1.7	34.52	27.81 ²	- 4 -		0	-1.7	24.60	27.87
- 12 -		5*	-1.6	34.55	27.83	- 4 -		5*	-1.7	34.64	26.90
- 12 -		10*	-1.6	34.50	27.78	- 6 -		0	-1.8	34.64	27.90 ³
- 2 p. m.		0	-1.7	34.49	27.78 ¹	- 6 -		5*	-1.8	34.61	27.89
- 2 -		5*	-1.6	34.50	27.78	- 6 -		10*	-1.8	34.69	27.94
- 4 -		0	-1.5	34.51	27.79 ¹	- 8 -	-3.0° NE 1	0	-1.7	34.62	27.89 ³
- 4 -		5*	-1.5	34.49	27.77	- 8 -		5*	-1.7	34.62	27.89
- 6 -		0	-1.5	34.50	27.78 ¹	- 10 -		0	-1.7	34.77	28.01 ³
- 6 -		5*	-1.4	34.45	27.74	- 10 -		5*	-1.8	34.57	27.85
- 6 -	-0.3° SW 1	10*		34.48		- 10 -		10*	-1.8	34.66	27.92
- 8 -		0	-1.5	34.52	27.80 ¹	12 midn.	71°18' N 43°52' E	0	-1.7	34.55	27.83 ³
- 8 -		5*	-1.5	34.48	27.74	- 12 -		5*	-1.8	34.56	27.84
- 11:25 -	71°12' N 44°10' E	0	-1.6	34.51	27.79 ¹	- 12 -		10*	-1.8	34.63	27.93
23, 2 a. m.		0	-1.7	34.51	27.80 ¹	- 12 -		15*	-1.9	34.95	28.16
- 2 -	71° 4' N 44°13' E	5*	-1.6	34.49	27.77	- 12 -		20*	-1.9	[35.17]?	
- 4 -		0	-1.5	34.51	27.79 ¹	25, 2 a. m.		0	-1.7	34.56	27.84 ³
- 4 -		5*	-1.5	34.51	27.79	- 2 -		5*	-1.8	34.57	27.85
- 6 -		0	-1.6	34.49	27.77 ¹	- 4 -		0	-1.7	[35.31]?	
- 6 -		5*	-1.4	34.54	27.82	- 4 -		5*	-1.7	34.54	27.83
- 6 -	-0.5° WSW 2	10*	-1.5	34.60	27.86	- 6 -		0	-1.7	34.55	27.83 ³
- 8 -		0	-1.5	34.60	27.86 ¹	- 6 -		5*	-1.7		
- 8 -		5*	-1.5	34.59	27.86	- 8 -	-4.0° NE 1	10*	-1.7	[35.29]?	
- 10 -		0	-1.7			- 8 -		0	-1.7	34.55	27.83 ⁴
- 10 -		5*	-1.6	34.70	27.85	- 10 -		5*	-1.8	[35.13]?	
- 12 noon	71°22' N 43°55' E	0	-1.7	34.58	27.86 ¹	- 12 noon	71°22' N 43°53' E	0	-1.7	34.53	27.82 ⁴
- 12 -		5*	-1.6	34.56	27.83	- 2 p. m.		0	-1.7	34.51	27.80 ⁴
- 12 -		10*	-1.6	34.58	27.85	- 4 -		0	-1.6	34.54	27.83 ⁴
- 2 p. m.		0	-1.7	34.56	27.84 ¹	- 6 -		0	-1.6	34.55	27.83 ⁵
- 2 -		5*	-1.6	34.56	27.83	- 8 -	-3.2° NE 2.5	0	-1.6	34.86	28.07 ⁵
- 4 -		0	-1.7	34.61	27.89 ¹			0	-1.6	34.57	27.84 ⁵

¹ In open sea. Sea gray. ² Along the ice-edge. Sea gray. ³ Along the ice-edge. ⁴ In the sea. ⁵ In open water. Sea gray.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
May 1901						May 1901					
25, 9 p. m.	72° 5' N 42° 20' E	0	-1.6	34.47	27.76 ¹	27, 12 noon	-7.1 NW 2	15*		34.70 ?	9
- 10 -		0	-1.6	34.47	27.76 ¹	- 12 -		20*		[34.45] ?	
- 11 -		0	-1.6	34.46	27.75 ¹	- 2 p. m.		0		34.86	
- 12 midn.		0	-1.4	34.47	27.76 ¹	- 2 -		5*		[Above 36.0/00]	
26, 1 a. m.	-4.7° N 1.5	0	-1.3	34.58	27.85 ²	- 4 -	72° 45' N 37° 00' E	5*		[35.09] ?	9
- 2 -		0	-1.3	34.58	27.85 ²	- 6 -		0		34.86 ?	
- 3 -		0	-1.4	34.65	27.90 ²	- 6 -		5*		34.17 ?	
- 4 -		0	-1.3	34.64	27.89 ²	- 6 -		10*		[35.41] ?	
- 5 -		0	-1.3	34.71	27.85 ²	- 8 -		0		34.92	9
- 6 -		0	-1.3	34.69	27.93 ²	- 8 -		5*		34.90	
- 7 -		0	-1.6	34.75	27.99 ²	- 10 -		0		34.88	9
- 8 -		0	-1.6	34.73	27.97 ³	- 10 -		5*		[35.79] ?	
- 9 -		0	-1.6	34.78	28.02 ⁴	- 12 midn.		0		34.84	9
- 10 -		0	-1.5	34.79	28.02 ⁴	- 12 -		10*		[Above 36.0/00]	
- 11 -		0	-1.8	34.79	28.03 ⁴	- 12 -		0		34.91	9
- 12 noon	72° 43' N 39° 30' E	0	-1.7	34.76	28.00 ⁴	28, 2 a. m.	-4.5° NW 1.5	0		[Above 36.0/00]	
- 1 p. m.	-5.8° NNE 3	0	-1.7	34.81	28.05 ⁴	- 2 -		5*		34.85	10
- 2 -		0	-1.8	34.79	28.03 ⁴	- 4 -		0		34.89	
- 3 -		0	-1.6	34.81	28.04 ⁵	- 6 -		0		34.89	10
- 4 -		0	-1.8	34.84	28.06 ⁶	- 8 -		0		34.84	
- 5 -		0	-1.8	34.97 ?	28.18 ⁶	- 10 -		0		34.80	10
- 6 -		0	-1.8	34.86	28.08 ⁶	- 12 noon		0		34.80	
- 7 -		0	-1.8	34.95 ?	[28.15] ⁷	- 12 -		5*		34.80	10
- 8 -		5*	-1.8	34.77	28.01 ⁶	- 12 -		10*		34.80	
- 8 -		10*	-1.8	34.31 ?	[27.64] ⁸	- 12 -		15*		34.79	10
- 8 -		15*	-1.8	34.94 ?	28.15 ⁶	- 12 -		20*		34.78	
- 8 -		20*	-1.4	34.54 ?	27.82 ²⁰	- 2 p. m.		0		34.81	10
- 10 -	73° 0' N 37° 5' E	0		34.90	7	- 4 -		0		34.84	
- 10 -		5*		[35.08] ?		- 6 -		0		34.83	11
- 12 midn.		0		34.91	8	- 8 -		0		34.83	
- 12 -		5*		[35.45] ?		- 10 -		0		34.72	11
- 12 -		10*		[Above 36.0/00]		- 12 midn.		0		34.79	
27, 2 a. m.		0		34.83	8	29, 2 a. m.	-4.0° NW 2.5	0		34.75	12
- 2 -		5*		[Above 36.0/00]		- 2 -		5*		34.72	
- 4 -		0		34.85	8	- 2 -		10*		34.75	12
- 4 -		5*		[Above 36.0/00]		- 2 -		15*		34.73	
- 6 -		0		34.90	8	- 4 -		20*		34.79	12
- 6 -		5*		34.21 ?		- 4 -		0		34.76	
- 6 -		10*		[35.38] ?		- 6 -		5*		34.79	12
- 8 -		0		34.88	8	- 6 -		0		34.88	
- 8 -		5*		[35.43] ?		- 8 -		5*		34.75	12
- 10 -		0		34.74	8	- 8 -		0		34.75	
- 12 noon	72° 50' N 37° 00' E	0		34.95 ?	8	- 10 -		0		34.78	12
- 12 -	72° 47' N 36° 55' E	5*		34.76 ?		- 12 midn.		5*		34.77	
- 12 -		10*		34.70 ?		- 12 -		0		34.81	12
								5*		34.75	

¹ In open water. Sea gray. ² In open water. Sea brown. ³ In open water. Sea brownish gray.
⁴ Ice-sludge and small rounded pieces of ice. ⁵ In the ice. ⁶ The temperature is unreliable. ⁷ During the following days the water-temperature could not be determined, owing to the low temperature of the air and the wind. The samples taken with the Amundsen Water-Bottle from 5-20 metres give obviously much too high salinities owing to formation of ice on the bottle. ⁸ Amongst small ice-pieces. Sea brownish gray.
⁹ Along the ice-edge. Sea brownish gray. ¹⁰ Along ice-edge. Sea brownish gray. ¹¹ In open sea. Sea brownish gray. ¹² Through newly formed pancake-ice. Sea brownish gray.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
May 1901		M.	° C.	‰		May 1901		M.	° C.	‰	
29, 12 noon		10*		34.75		31, 10 p. m.		0	-1.1	34.77	27.99 ²
- 12 -		15*		34.65 [?]		- 12 midn.	73°10' N 36°30' E	0	-1.5	34.77	28.00 ²
- 2 p. m.		0		34.78	1	- 12 -		5*	-1.2	34.85	28.05 ³
- 4 -		0		34.71	1						
- 4 -		5*		34.77							
- 6 -		0		34.83	2	June 1901					
- 6 -		5*		34.76		1, 2 a. m.		0	-1.5	34.78	28.01 ³
- 6 -		10*		34.76		- 4 -		0	-1.5	34.44	27.74 ³
- 8 -	-4.5° NW 2	0		34.81	2	- 6 -		0	-1.5	34.78	28.01 ⁴
- 8 -		5*		34.77		- 8 -	0.5 S 2	0	-1.5	34.79	28.02 ⁴
- 10 -		0		34.77	2	- 8 -		5*	-1.5	34.82	28.05
- 10 -		5*		34.75		- 10 -		0	-1.4	34.77	28.00 ⁴
- 12 midn.	72°43' N 36° 5' E	0		34.78	2	- 12 noon	73°19' N 36°00' T	0	-1.4	34.77	28.00 ⁵
- 12 -		5*		34.76		- 2 p. m.		0	-1.3	34.77	28.00 ⁵
30, 2 a. m.		0		34.79	2	- 2 -		5*	-1.2	34.77	27.99
- 2 -		5*		34.79		- 2 -		10*	-1.2	34.79	28.01
- 4 -		0		34.85	2	- 2 -		15*	-1.2	34.83	28.04
- 4 -		5*		34.78		- 2 -		20*	-1.2	34.77	27.99
- 6 -		0		34.86	2	- 2 -		25*	-0.8	34.79	28.00
- 8 -	-4.3° NW 2	0		34.78	2	- 4 -		0	-1.3	34.79	28.02 ⁵
- 10 -		0		34.87	2	- 4 -		5*	-1.3	34.80	28.03
- 12 noon	72°48' N 36°48' E	0		34.81	2	- 6 -	73°22' N 36° 5' E	0	-1.4	34.77	28.00 ⁵
- 2 p. m.		0		34.87	2	- 8 -	-0.2° SW 1.5	0	-1.4	34.79	28.02 ⁵
- 4 -		0		34.85	2	- 8 -		5*	-1.4	34.77	28.00
- 6 -	72°52' N 36°50' E	0		34.91	2	- 10 -		0	-1.5	34.78	28.01 ⁵
- 8 -	-2.8° NW 2	0		34.85	2	- 12 midn.	73°25' N 38°21' E	0	-1.5	34.79	28.02 ⁵
- 8 -		5*		34.81		2, 2 a. m.		0	-1.6	34.76	27.99 ⁵
- 8 -		10*		34.81		- 2 -		5*	-1.1	34.76	27.98
- 8 -		15*		34.81		- 4 -		0	-1.5	34.79	28.02 ⁵
- 8 -		20*		34.83		- 4 -		0	-1.5	34.77	28.00
- 8 -		25*		34.83		- 6 -		0	-1.5	34.77	28.00 ⁵
- 10 -		0		34.87	2	- 6 -		5*	-1.5	34.77	28.00
- 12 midn.	73° 0' N 36°48' E	0		34.79	2	- 6 -		10*	-1.5	34.76	27.99
- 12 -		5*		34.85		- 8 -	-2.0 W 2	0	-1.4	34.79	28.02 ⁵
31, 2 a. m.		0		34.86	2	- 8 -		5*	-1.4	34.79	28.02
- 4 -		0		34.85	2	- 10 -		0	-1.6	34.77	28.00 ⁵
- 6 -		0		34.79	2	- 10 -		5*	-1.3	34.80	28.03
- 6 -		5*		34.77		- 12 noon	73°27' N 38°19' E	0	-1.6	34.78	28.01 ⁵
- 6 -		10*		34.85		- 12 -		5*	-1.6	34.76	27.99
- 8 -	-3.8 NW 1	0		34.88	2	- 12 -		10*	-1.5	34.75	27.99
- 8 -		5*		34.83		- 12 -		15*	-1.5	34.76	27.99
- 10 -	73° 7' N 36°43' E	0		34.88	2	- 12 -		20*	-1.4	34.80	28.03
- 12 noon	73° 5' N 36°35' E	0	-0.7	34.79	27.99 ²	- 12 -		25*	-1.1	34.80	28.02
- 12 -		15*		34.79		- 2 p. m.		0	-1.5	34.76	27.99 ⁵
- 12 -		20*		34.83		- 4 -		5*	-1.3	34.79	28.01
- 12 -		25*		34.83		- 4 -		0	-1.5	34.75	27.99 ⁵
- 2 p. m.		0	-0.8	34.69	27.91 ²	- 6 -		5*	-1.4	34.77	28.00
- 4 -		0	-0.8	34.85	28.04 ²	- 6 -		0	-1.5	34.77	28.00 ⁵
- 4 -		5*	-0.8	34.93	28.11	- 8 -	-1.0° WSW 2	10*	-1.4	34.76	27.99
- 6 -	73°10' N 36°40' E	0	-0.7	34.83	28.02 ²	- 10 -		0	-1.5	34.76	27.99 ⁵
- 8 -	-0.5 SW 1.5	0	-0.5	34.82	28.01 ²	- 12 midn.	73°25' N 38°10' E	0	-1.4	34.78	28.00 ⁵

¹ Through newly formed pancake-ice. Sea brownish gray. ² Along ice-edge. Sea brownish gray.
³ In open water. Sea gray. ⁴ Amongst small ice-pieces. ⁵ Along ice-edge. Sea gray.

Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
June 1901		M.	° C.	‰		June 1901		M.	° C.	‰	
3, 2 a. m.		0	-1.3	34.80	28.03 ¹	5, 8 p. m.	0° S 2	0	-1.3	34.52	27.80 ³
- 4 -		0	-1.3	34.85	28.06 ¹	- 10 -		0	-1.2	34.51	27.78 ³
- 6 -		0	-1.3	34.80	28.03 ¹	- 12 midn.	74°41' N 36°35' E	0	1.7	34.94	27.97 ⁴
- 6 -		5*	-1.2	34.80	28.02	6, 2 a. m.		0	0.8	34.88	27.98 ⁴
- 6 -		10*	-1.1	34.84	28.04	- 4 -		0	0.8	34.65	27.79 ⁴
- 6 -		15*	-1.1	34.84	28.04	- 6 -		0	0.0	34.56	27.77 ⁴
- 6 -		20*	-1.0	34.84	28.04	- 8 -	2.0° S 1.5	0	-0.2	34.63	27.84 ⁴
- 6 -		25*	-0.7	34.84	28.04	- 10 -		0	-0.7	34.65	27.87 ⁴
- 8 -	-0.1° Calm	0	-1.2	34.84	28.05 ¹	- 10 -		5*	-0.3	34.69	27.86
- 8 -		5*	-1.3	34.84	28.05	- 12 -	74°29' N 31°30' E	0	-0.9	34.63	27.87 ⁵
- 10 -		0	-1.1	34.83	28.04 ¹	- 12 -		5*	-0.7	34.69	27.86
- 12 noon	73°20' N 37°58' E	0	-1.1	34.81	28.03 ¹	- 2 p. m.	74°45' N 31°5' E	0	-1.0	34.53	27.79 ⁵
- 2 p. m.		0	-1.1	34.80	28.02 ¹	- 4 -		0	-0.6	34.61	27.91 ⁵
- 4 -		0	-1.1	34.83	28.04 ¹	- 6 -		0	-0.2	34.56	27.78 ⁵
- 6 -		0	-1.1	34.80	28.02 ¹	- 8 -	3.8° S 2	0	0.2	34.46	27.68 ⁶
- 8 -	-0.3 E b S 2	0	-1.1	34.76	27.98 ¹	- 10 -		0	-0.2	34.17	27.47 ⁵
- 10 -		0	-1.2	34.77	27.99 ¹	- 12 midn.	74°45' N 29°55' E	5*	0.1	34.35	27.60
- 12 midn.	73°20' N 38° 5' E	0	-1.3	34.70	27.95 ¹	7, 2 a. m.		0	0.0	34.12	27.41 ⁵
4, 2 a. m.		0	-1.3	34.57	27.84 ¹	- 2 -		0	-0.5	33.96	27.31 ⁵
- 4 -		0	-1.4	34.63	27.89 ¹	- 4 -		5*	0.0	33.95	27.28
- 4 -		5*	-1.4	34.63	27.89	- 6 -		0	-0.2	34.00	27.33 ⁵
- 6 -		0	-1.4	34.70	27.95 ¹	- 8 -	3.0° S 1.5	0	-0.2	33.96	27.30 ⁵
- 6 -		5*	-1.4	34.66	27.91	- 10 -		0	0.0	34.00	27.32 ⁵
- 6 -		10*	-1.3	34.63	27.88	- 12 noon	74°40' N 30°00' E	0	-0.3	33.94	27.29 ⁵
- 8 -	-1.3° NE 1	0	-1.3	34.69	27.93 ¹	- 2 p. m.		0	-0.3	33.93	27.28 ⁵
- 8 -		5*	-1.3	34.70	27.95	- 4 -		5*	0.0	33.94	27.27
- 10 -		0	-1.3	34.71	27.95 ²	- 6 -		0	-0.5	34.08	27.42 ⁵
- 10 -		5*	-1.2	34.71	27.95	- 8 -		0	-0.6	33.93	27.29 ⁵
- 10 -		10*	-1.2	34.73	27.96	- 10 -		5*	-0.5	33.91	27.27
- 10 -		15*	-1.2	34.70	27.94	- 12 midn.	74°46' N 26°22' E	0	-0.8	34.01	27.37 ⁵
- 10 -		20*	-1.1	34.70	27.94	- 2 a. m.		5*	-0.7	34.00	27.35
- 12 noon	72°54' N 38°18' E	0	-1.3	34.70	27.95 ²	- 4 -		0	-1.1	34.02	27.39 ⁶
- 2 p. m.		0	-1.3	34.70	27.95 ²	- 6 -		5*	-0.9	34.02	27.38
- 4 -		0	-1.3	34.70	27.95 ²	- 8 -	2.0° SSW 2	0	-1.1	34.01	27.38 ⁶
- 4 -		5*	-1.2	34.73	27.96	- 10 -		0	-1.1	33.98	27.36 ⁶
- 6 -		0	-1.0	34.70	27.94 ²	- 12 midn.	74°46' N 26°22' E	0	-1.0	34.11	27.45 ⁶
- 6 -		5*	-1.2	34.70	27.94	- 2 a. m.		5*	-1.0	34.05	27.40
- 8 -	-1.0° NNE 1	0	-1.3	34.70	27.95 ²	- 4 -		10*	-1.0	34.08	27.43
- 8 -		5*	-1.2	34.70	27.94	- 6 -		0	-0.8	34.07	27.42 ⁶
- 10 -		0	-1.3	34.71	27.95 ²	- 8 -		5*	-0.8	34.05	27.40
- 10 -		5*	-1.2	34.70	27.94	- 10 -		0	-1.0	34.04	27.39 ⁶
- 12 midn.	73°50' N 37°50' E	0	-1.2	34.68	27.92 ²	- 12 noon	74°30' N 25°2' E	5*	-0.9	34.05	27.40 ⁶
5, 6 a. m.		0	-0.8	34.61	27.86 ²	- 12 -		5*	-0.9	34.05	27.40
- 6 -		5*	-1.2	34.66	27.90	- 12 -		10*	-0.9	34.09	27.43
- 8 -		0	-1.0	34.41	27.69 ²	- 12 -		15*	-0.9	34.07	27.42
- 8 -	0° SW 0.5	5*	-1.0	34.51	27.78	- 12 -		20*	-0.9	34.07	27.42
- 10 -	73°50' N 37°50' E	0	-0.7		²	- 2 p. m.		0	-1.0	34.07	27.42 ⁶
- 10 -		5*	-0.6	34.59	27.82	- 2 -		5*	-0.7	34.99	27.42
- 12 noon	74°00' N 30°35' E	0	-0.8	34.44	27.71 ²						
- 2 -		0	-0.9	34.42	27.69 ²						
- 4 -		0	-0.9	34.57	27.82 ³						
- 6 -		0	-1.3	34.54	27.82 ³						

¹ Along ice-edge. Sea gray. ² Along ice-edge. Sea grayish green. ³ In open sea. Sea grayish green.
⁴ In open sea. Sea dirty green. ⁵ Along ice-edge. Sea brighter green. ⁶ Along ice-edge. Sea green.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Temperature	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Temperature	Salinity ‰	σ_t
June 1901		M.	° C.	‰		June 1901		M.	° C.	‰	
8, 4 p. m.		0	-1.0	34.09	27.43 ¹	10, 12 noon		5*	0.02	33.84	27.19
- 4 -		5*	-1.0	34.09	27.43	- 2 p. m.		0	-0.25	33.59	27.01 ⁸
- 6 -		0	-1.0	34.03	27.39 ¹	- 4 -		0	1.19	34.27	27.47 ⁸
- 6 -		5*	-1.0	34.01	27.37	- 4 -		5*	1.92	34.29	27.43
- 6 -		10*	-1.0	34.08	27.43	- 6 -		0	1.2	34.24	27.45 ⁸
- 8 -	0.5° WNW 2.5	0	-0.8	33.99	27.35 ¹	- 8 -	0° ENE 2	0	0.92	34.32	27.52
- 8 -		5*	-0.7	33.99	27.35	- 8 -		5*	1.0	34.32	27.52
- 10 -		0	-1.0	33.97	27.34 ¹	- 10 -		0	0.42	33.91	27.53
- 10 -		5*	-0.8	34.01	27.37	- 12 midn.	73°58' N 26°45' E	0	1.02	34.37	27.56
- 12 midn.	74°30' N 25°17' E	0	-1.0	34.01	27.37 ¹	11, 2 a. m.		0	0.29	33.96	27.21
- 12 -		5*	-1.0	34.04	27.39	- 2 -		5*		33.82	
- 12 -		10*	-1.0	34.03	27.39	- 4 -		0	0.83	34.26	27.48 ⁴
- 12 -		15*	-0.9	34.04	27.39	- 6 -		0	1.24	33.62	26.95 ⁴
- 12 -		20*	-0.7	34.06	27.40	- 8 -	0.2° ENE 3	0	0.43	34.12	27.39 ⁴
9, 2 a. m.		0	-1.0	34.01	27.37 ¹	- 10 -		0	-0.26	34.05	27.37 ⁴
- 2 -		5*	-0.9	33.99	27.36	- 11 -		0	-0.3	34.03	27.36 ⁴
- 4 -		0	-1.0	34.03	27.39 ¹	- 12 noon	73°38' N 24°50' E	0	0.4	34.17	27.44 ⁴
- 4 -		5*	-0.9	33.99	27.36	- 1 p. m.		0	0.79	34.20	27.43 ⁴
- 6 -		0	-1.0	33.99	27.36 ¹	- 2 -		0	0.93	34.36	27.56 ⁴
- 6 -		5*	-1.0	34.02	27.38	- 3 -		0	0.72	34.27	27.50 ⁴
- 6 -	-0.5° NW 2	10*	-1.0	34.00	27.36	- 4 -		0	1.46	34.53	27.65 ⁴
- 8 -		0	-1.0	34.03	27.39 ¹	- 5 -		0	2.43	34.91	27.90 ⁴
- 8 -		5*	-1.0	34.05	27.40	- 6 -	73°12' N 24°24' E	0	3.41	34.97	27.85 ⁴
- 10 -		0	-0.9	34.01	27.37 ¹	- 7 -		0	3.65	35.03	27.86 ⁴
- 12 noon	74°12' N 26°30' E	0	-0.7	34.04	27.38 ²	- 8 -	2.0° E 2.5	0	3.40	35.05	27.93 ⁴
- 12 -		5*	-0.6	34.04	27.38	- 9 -		0	2.75	34.94	27.99 ⁴
- 2 p. m.		0	-0.4	34.04	27.37 ²	- 10 -		0	3.25	34.99	27.88 ⁴
- 2 -		5*	-0.3	34.12	27.43	- 11 -		0	3.28	35.01	27.89 ⁴
- 4 -		0	0.5	34.23	27.48 ²	- 12 midn.	73°43' N 21° 7' E	0	2.88	35.01	27.93 ⁵
- 4 -		5*	0.5	34.19	27.45	12, 1 a. m.		0	3.04	34.99	27.90 ⁴
- 6 -		0	0.5	34.18	27.44 ²	- 2 -		0	2.98	34.99	27.91 ⁴
- 6 -		5*	0.6	34.20	27.45	- 3 -		0	1.21	34.75	27.86 ⁴
- 6 -		10*	1.4	34.57	27.70	- 4 -		0	0.21	34.69	27.87 ⁴
- 6 -		15*	1.56	34.59	27.70	- 5 -		0	-0.7	34.94	28.11 ⁴
- 6 -		20*	2.00	34.76	27.81	- 6 -		0	-0.5	35.08	28.22 ⁴
- 6 -		25*	2.18	34.80	27.82	- 7 -		0	-0.3	34.71	27.91 ⁵
- 8 -	0.4° WNW 0.5	0	0.43	34.21	27.46 ²	- 8 -	-1.4° NE 2	0	-0.5	34.70	27.92 ⁵
- 8 -		5*	0.69	34.19	27.44	- 9 -		0	-0.18	34.70	27.90 ⁵
- 10 -		0	0.37	34.18	27.44 ²	- 10 -		0	0.1	34.66	27.84 ⁵
- 10 -		5*	0.95	34.20	27.43	- 11 -		0	0.83	34.63	27.78 ⁵
- 12 midn.	74° 6' N 26°55' E	0	0.34	34.19	27.46 ²	- 12 noon	NW point of Bear Island in N, its south point in EbS	0	0.3	34.64	27.81 ⁵
- 12 -		5*	0.64	34.23	27.47	- 2 p. m.		0	0.3	34.69	27.86 ⁵
- 12 -		10*	1.2	34.33	27.51	- 4 -		0	0.3	34.65	27.82 ⁵
10, 2 a. m.		0	0.5	34.21	27.46 ²	- 6 -		0	0.3	34.71	27.88 ⁵
- 2 -		5*	1.0	34.25	27.46	- 8 -	-0.3° NE 2	0	0.3	34.63	27.80 ⁵
- 4 -		0	0.2	34.18	27.46 ²	- 10 -		0	0.2	34.58	27.78 ⁵
- 4 -		5*	0.79	34.21	27.44	- 10 -		5*	0.3	34.63	27.80
- 6 -		0	1.0	34.33	27.52 ²	- 12 midn.		10*	0.3	34.64	27.81
- 6 -		5*	1.0	34.35	27.55	13, 2 a. m.		0	-0.1	34.70	27.89 ⁵
- 6 -	-0.5 E 0.5	10*	1.5	34.59	27.71	- 4 -		0	-0.1	34.68	27.87 ⁵
- 8 -		0	0.8	34.23	27.47 ²	- 6 -		0	0.0	34.66	27.85 ⁵
- 8 -		5*	1.2	34.35	27.54	- 12 noon		0	-0.2	34.66	27.84 ⁵
- 10 -		0	0.5	34.14	27.41 ²						
- 10 -		5*	1.2	34.14	27.38						
- 12 noon	74°00' N 26°50' E	0	-0.81	33.55	26.99 ³						

¹ Along ice-edge. Sea green. ² Along ice-edge. ³ Through ice. Sea green. ⁴ In open sea. Sea green.

⁵ Sea light green.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
June 1901		M.	° C.	‰		June 1901		M.	° C.	‰	
13, 8 a. m.	1°0' N 1°0	0	-0.2	34.69	27.88 ¹	15, 1 p. m.		0	2.2	34.81	27.83 ²
- 8 -		5*	0.0	34.60	27.80	- 2 -		0	3.0	35.01	27.91 ²
- 10 -		0	0.0	34.66	27.85 ¹	- 3 -		0	1.8	34.81	27.86 ²
- 12 noon	Mount Misery in N b W, 2 miles off	0	0.1	34.64	27.83 ¹	- 4 -		0	0.8	34.61	27.76 ²
- 12 -		0	0.1	34.64	27.83 ¹	- 5 -		0	0.9	34.63	27.76 ²
- 2 p. m.		5*	0.3	34.62	27.80	- 6 -	73°40' N 7°18' E	0	0.5	34.60	27.77 ²
- 2 -		0	0.1	34.62	27.81 ¹	- 7 -		0	0.6	34.58	27.75 ²
- 4 -		5*	0.3	34.58	27.77	- 8 -	2°0' ENE 1.5	0	0.5	34.58	27.76 ²
- 6 -		0	0.1	34.64	27.83 ¹	- 9 -		0	0.6	34.61	27.78 ²
- 8 -		0	0.0	34.62	27.83 ¹	- 10 -		0	0.1	34.66	27.84 ²
- 10 -	-0°4' NE 2	0	0.0	34.66	27.85 ¹	- 11 -		0	0.2	34.66	27.85 ²
- 10 -		0	0.1	34.69	27.88 ¹	- 12 midn.	73°35' N 5°43' E	0	0.3	34.69	27.86 ²
- 12 midn.		5*	0.3	34.70	27.87 ¹	16, 1 p. m.		0	0.2	34.67	27.85 ²
14, 2 a. m.		0	0.4	34.65	27.85 ¹	- 2 -		0	0.2	34.64	27.82 ²
- 4 -		0	0.1	34.65	27.85 ¹	- 4 -		0	0.2	34.64	27.82 ²
- 5 -		0	-0.3	34.70	27.91 ¹	- 4 -		0	0.2	34.64	27.82 ²
- 6 -		0	0.6	34.79	27.92 ¹	- 5 -		0	0.2	34.63	27.81 ²
- 7 -		0	0.6	34.75	27.89 ¹	- 6 -	73°13' N 3°9' E	0	0.2	34.76	27.92 ¹
- 8 -	-1°0' NE 2	0	0.6	34.77	27.91 ¹	- 7 -		0	0.3	34.59	27.77 ¹
- 9 -		0	1.6	34.83	27.89 ²	- 8 -	2°0' NNW 2.5	0	0.2	34.64	27.82 ¹
- 10 -		0	2.9	34.92	27.86 ²	- 9 -		0	0.1	34.67	27.86 ¹
- 11 -		0	4.9	35.03	27.72 ²	- 10 -		0	0.2	34.68	27.86 ¹
- 12 noon		0	5.2	35.03	27.69 ²	- 11 -		0	0.2	34.65	27.84 ¹
- 1 p. m.	74°33' N 14°40' E	0	5.0	35.03	27.71 ²	- 12 -	73°3' N 1°33' E	0	0.3	34.54	27.75 ¹
- 2 -		0	5.2	34.98	27.66 ²	- 1 p. m.		0	0.8	34.55	27.71 ¹
- 3 -		0	5.2	34.98	27.66 ²	- 2 -		0	0.7	34.55	27.70 ¹
- 4 -		0	4.8	35.03	27.73 ²	- 3 -		0	0.3	34.64	27.81 ¹
- 5 -		0	4.3	35.07	27.79 ²	- 4 -		0	0.2	34.64	27.82 ¹
- 6 -	74°28' N 13°20' E	0	4.5	35.05	27.76 ²	- 5 -		0	0.4	34.70	27.87 ¹
- 7 -		0	4.5	35.09	27.77 ²	- 6 -	73°6' N 0°00' W & O	0	0.4	34.64	27.81 ¹
- 8 -	1°0' NE 1	0	4.5	35.05	27.76 ²	- 7 -		0	0.2	34.71	27.89 ¹
- 9 -		0	3.8	35.08	27.85 ²	- 8 -	1°0' N 2	0	0.0	39.79	27.99 ¹
- 10 -		0	3.4	35.09	27.88 ²	- 9 -		0	0.0	34.80	27.97 ¹
- 11 -		5*	3.5	35.08	27.87 ²	- 10 -		0	0.2	34.72	27.90 ¹
- 12 midn.		0	3.3	35.09	27.89 ²	- 11 -		5*	0.4	34.70	27.87 ¹
15, 1 a. m.	74°27' N 11°40' E	0	3.3	35.07	27.89 ²	- 12 midn.	73°15' N 1°25' W	0	0.2	34.72	27.90 ¹
- 2 -		0	2.9	35.09	27.93 ²	- 12 -		5*	0.4	34.70	27.87 ¹
- 2 -		0	2.9	35.05	27.92 ²	17, 1 a. m.		0	0.3	34.68	27.86 ¹
- 3 -		5*	3.2	35.06	27.90 ²	- 2 -		0	0.3	34.68	27.86 ¹
- 4 -		0	3.0	34.99	27.90 ²	- 2 -		5*	0.4	34.69	27.86 ¹
- 4 -		0	2.8	34.99	27.92 ²	- 3 -		0	0.2	34.74	27.92 ¹
- 5 -		5*	2.9	34.99	27.91 ²	- 4 -		0	0.1	34.76	27.94 ¹
- 6 -	74°00' N 11°30' E	0	2.8	35.05	27.94 ²	- 4 -		5*	0.6	34.76	27.90 ¹
- 6 -		0	3.0	35.05	27.92 ²	- 5 -		0	0.3	34.72	27.90 ¹
- 6 -		5*	3.1	35.07	27.92 ²	- 6 -	73°17' N 1°30' W	0	0.2	34.73	27.90 ¹
- 7 -		0	3.5	35.08	27.89 ²	- 6 -		5*	0.6	34.73	27.88 ¹
- 8 -	3°0' NE 1	0	2.6	34.94	27.90 ²	- 7 -		0	0.2	34.78	27.95 ¹
- 8 -		5*	2.8	34.96	27.89 ²	- 8 -	2°6' N 1	0	0.3	34.73	27.91 ¹
- 9 -		0	1.1	34.65	27.78 ²	- 8 -		5*	0.9	34.76	27.89 ¹
- 10 -		0	1.3	34.70	27.81 ²	- 10 -		0	0.3	34.68	27.85 ¹
- 11 -		0	2.4	34.81	27.82 ²						
- 12 midn.	73°48' N 10°00' E	0	2.6	34.89	27.86 ²						

¹ Sea light green. ² In open sea. Sea green.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
June 1901		M.	° C.	‰		June 1901		M.	° C.	‰	
17, 10 a. m.		5*	0.4	34.69	27.86	19, 12 noon	{ 74°8' N 3°25' W	0	-0.2		3
- 10 -		10*	0.5	34.67	27.83	- 2 p. m.		0	-0.2		3
- 10 -		15*	0.5	34.68	27.84	- 4 -		0	-0.5		3
- 10 -		20*	0.5	34.71	27.87	- 6 -		0	-0.5		3
- 10 -		25*	1.0	34.68	27.81	- 8 -		0	0.0		3
- 12 noon	{ 73°40' N 1°50' W	0	1.8	34.68	27.84 ¹	- 10 -	1°0' SSW 1.5	0	0.0		3
- 12 -		5*	0.7	34.67	27.82	- 12 midn.		0	-0.2	34.29	27.56 ⁴
- 12 -		10*	0.6	34.67	27.82	- 12 -		5*	0.0	34.26	27.52
- 2 p. m.		0	0.9	34.69	27.83 ¹	- 12 -	{ 74°10' N 3°25' W	10*	0.1	34.30	27.54
- 2 -		5*	2.6	34.68	27.76	20, 2 a. m.		0	-0.3	34.23	27.52 ⁴
- 4 -		0	1.5	34.70	27.79 ¹	- 4 -		0	0.2	34.48	27.72 ⁴
- 4 -		5*	1.1	34.73	27.84	- 4 -		5*	0.3	34.48	27.72
- 6 -	{ 73°44' N 2°10' W	0	1.5	34.73	27.82 ¹	- 6 -	{ 74°11' N 3°22' W	0	0.2	34.37	27.61 ⁴
- 6 -		5*	0.9	34.69	27.83	- 6 -		5*	0.2	34.37	27.61
- 6 -		10*	1.1	34.72	27.84	- 6 -		10*	0.2	34.40	27.63
- 8 -	2°0' W 1	0	0.8	34.63	27.78 ¹	- 8 -	1°8' SW 1	0	0.2	34.41	27.63 ⁴
- 8 -		5*	0.6	34.62	27.78	- 8 -		5*	0.2	34.35	27.59
- 10 -		0	0.7	34.68	27.83 ¹	- 10 -		0	0.2	34.38	27.62 ⁴
- 12 midn.	{ 73°50' N 3°20' W	0	0.2	34.43	27.66 ¹	- 10 -		5*	0.4	34.41	27.62
18, 1 a. m.		0	0.2	34.35	27.59	- 12 noon	{ 74°12' N 3°22' W	0	0.2	34.38	27.62 ⁴
- 2 -		0	0.2	34.36	27.60 ¹	- 12 -		5*	0.3	34.38	27.61
- 3 -		0	-0.1	34.32	27.58 ¹	- 12 -		10*	0.3	34.37	27.60
- 4 -		0	-0.2	34.34	27.61 ¹	- 2 p. m.	{ 74°5' N 3°27' W	0	0.2	34.41	27.63 ⁴
- 5 -		0	-0.2	34.41	27.65 ¹	- 6 -	{ 74°13' N 3°21' W	0	0.2	34.42	27.64 ⁴
- 6 -	{ 73°57' N 4°55' E	0	-0.2	34.28	27.56 ²	- 6 -		5*	0.2	34.43	27.66
- 7 -		0	-0.2	34.11	27.42 ²	- 6 -		10*	0.3	34.45	27.66 ⁴
- 8 -	-0°3' W 1	0	-0.3	34.19	27.49 ²	- 6 -		0	0.2	34.26	27.52 ⁴
- 8 -		5*	0.5	34.29	27.52	- 8 -	1°6' S 1	5*	0.3	34.27	27.52 ⁴
- 10 -		0	-0.3	34.03	27.36 ²	- 10 -		0	0.3	34.45	27.66 ⁴
- 10 -		5*	0.0			- 10 -		5*	0.3	34.42	27.63
- 10 -		10*	0.0	34.30	27.55	- 12 midn.	{ 74°14' N 3°21' W	0	0.3	34.46	27.67 ⁴
- 12 noon	{ 73°59' N 3°35' W	0	0.0	34.34	27.60 ³	- 12 -		5*	0.4	34.46	27.67
- 2 p. m.		0	0.2	34.08	27.38 ³	- 12 -		10*	0.4	34.46	27.67 ⁴
- 4 -		0	-0.2	34.14	27.45 ³	- 2 a. m.		0	0.3	34.46	27.67 ⁴
- 6 -	{ 74°5' N 3°30' W	0	-0.2	34.10	27.41 ³	- 2 -		5*	0.4	34.46	27.67 ⁴
- 8 -	0°2' SW 1.5	0	-0.2	34.00	27.33 ³	- 4 -		0	0.2	34.55	27.75 ⁴
- 8 -		5*	-0.1	34.10	27.39 ³	- 4 -		5*	0.3	34.53	27.73
- 10 -		0	-0.2	34.05	27.37 ³	- 6 -	{ 74°15' N 3°20' W	0	0.3	34.64	27.82 ⁴
- 10 -		5*	-0.2	34.05	27.37	- 6 -		5*	0.3	34.67	27.85
- 12 -	{ 74°00' N 3°33' W	0	-0.1	34.14	27.44 ³	- 6 -		10*	0.3	34.67	27.85 ⁴
- 12 -		5*	0.0	34.10	27.39	- 8 -	2°0' SSE 1	0	-0.3	34.67	27.88 ⁴
- 12 -		10*	-0.1	34.26	27.53 ³	- 10 -		5*	-0.4	34.64	27.85 ⁴
19, 2 a. m.		0	-0.2	34.18	27.48 ³	- 10 -		0	0.5	34.62	27.79 ⁴
- 4 -		0	-0.2	34.12	27.43 ³	- 10 -		5*	0.7	34.62	27.78
- 4 -		5*	-0.1	34.11	27.41	- 12 noon	{ 74°15' N 3°20' W	0	0.5	34.63	27.80 ⁴
- 6 -	{ 74°4' N 3°30' W	0	-0.2	34.12	27.43 ³	- 12 -		5*	0.7	34.63	27.79
- 6 -		5*	-0.1	34.17	27.46	- 12 -		10*	0.7	34.62	27.79
- 6 -		10*	-0.5	34.33	27.60 ³	- 2 p. m.		0	0.6	34.67	27.82 ⁴
- 8 -	1°0' SW 1	0	-0.2	34.17	27.47 ³	- 2 -		5*	0.7	34.67	27.82
- 8 -		5*	-0.1	34.15	27.45	- 4 -		0	0.5	34.64	27.81 ⁴
- 10 -		0	-0.2	34.09	27.40						

¹ Sea light green. ² Through ice. ³ Along ice-edge. ⁴ Along ice-edge. Sea light green.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
June 1901		M	° C.	‰		June 1901		M.	° C.	‰	
21, 4 p. m.		5°	0.5	34.66	27.82	23, 10 a. m.		5°	0.7	34.38	27.59
- 6 -	74°14' N	0	0.5	34.64	27.81 ¹	- 12 noon	74°12' N	0	0.7	34.44	27.64 ²
- 6 -	3°20' W	5°	0.6	34.67	27.83	- 12 -	3°15' W	5°	0.8	34.44	27.63
- 6 -		10°	0.6	34.61	27.77	- 12 -		10°	0.8	34.46	27.64 ²
- 8 -	1.9° S 1	0	0.4	34.63	27.80 ¹	- 2 p. m.		0	0.7	34.49	27.67
- 8 -		5°	0.5	34.62	27.79	- 2 -		5°	0.8	34.53	27.70
- 10 -		0	0.4	34.63	27.80 ¹	- 4 -		0	0.7	34.49	27.67 ²
- 10 -		5°	0.5	34.67	27.83	- 4 -		5°	0.6	34.51	27.69
- 12 midn.	74°12' N	0	0.5	34.70	27.86 ¹	- 6 -	74°14' N	0	0.7	34.52	27.70 ²
- 12 -	3 19' W	5°	0.6	34.70	27.85	- 6 -	3°10' W	5°	0.7	34.57	27.74
- 12 -		10°	0.6	34.70	27.85	- 6 -		10°	0.8	34.57	27.73
22, 2 a. m.		0	0.4	34.70	27.87 ¹	- 8 -	1.8° W 1	0	0.6	34.65	27.81
- 2 -		5°	0.6	34.70	27.85	- 8 -		5°	0.7	34.67	27.82
- 4 -		0	0.3	34.70	27.87 ¹	- 10 -		0	0.7	34.76	27.82
- 4 -		5°	0.4	34.70	27.87	- 12 midn.	74°15' N	0	0.3	34.74	27.90 ³
- 6 -	74°11' N	0	0.3	34.70	27.87 ¹	- 12 -	3°7' W	5°	0.4	34.73	27.89
- 6 -	3 19' W	5°	0.4	34.70	27.87	24, 0.10 a. m.		0	0.6	34.73	27.88
- 6 -		10°	0.5	34.68	27.84	- 2 -		5°	0.6	34.74	27.88 ³
- 8 -	2.1° SSE 1.5	0	0.4	34.67	27.84 ¹	- 2 -		0	0.5		
- 8 -		5°	0.5	34.70	27.86	- 2 -		5°	0.5	34.79	27.94 ³
- 10 -		0	0.4	34.70	27.87 ¹	- 4 -		0	0.5		
- 10 -		5°	0.6	34.70	27.85	- 4 -		5°	0.6	35.10	28.18
- 12 noon	74°10' N	0	0.5	34.70	27.86 ¹	- 6 -	74°17' N	0	0.5	34.70	27.86 ³
- 12 -	3°19' W	5°	0.7	34.70	27.85	- 6 -	3°3' W	5°	0.6	34.73	27.88
- 12 -		10°	0.8	34.70	27.84	- 6 -		10°	0.6	35.11	28.18 ³
- 12 -		15°	0.8	34.70	27.84	- 8 -	1.5° WSW 1.5	0	0.6		
- 12 -		20°	0.8	34.69	27.84	- 8 -		5°	0.5	34.73	27.90 ³
- 12 -		25°	0.8	34.70	27.84	- 10 -		0	0.7		
- 2 p. m.		0	0.6	34.76	27.90 ¹	- 10 -		3°	0.8	34.74	27.87
- 2 -		5°	0.7	34.70	27.85	- 12 noon	74°18' N	0	0.6	34.62	27.78 ³
- 4 -		0	0.6	34.67	27.82 ¹	- 12 -	3°00' W	3°	0.7	34.62	27.78 ¹
- 4 -		5°	0.6	34.68	27.83	- 2 p. m.		0	0.4		
- 6 -	74°10' N	0	0.7	34.67	27.82	- 2 -		5°	0.6	34.67	27.82 ¹
- 6 -	3°18' W	5°	0.7	34.61	27.77	- 4 -		0	0.1		
- 6 -		10°	0.7	34.63	27.78	- 4 -		5°	0.2	34.79	27.95
- 8 -	1.9° S b W 1	0	0.7	34.59	27.75 ¹	- 6 -	74°16' N	0	0.2	34.84	28.00 ¹
- 8 -		5°	0.7	34.60	27.76	- 6 -	2°30' W	3°	0.4	34.61	27.79 ¹
- 10 -		0	0.7	34.61	27.77 ¹	- 8 -	0.5° W 1.5	0	0.4		
- 10 -		5°	0.8	34.62	27.77	- 8 -		3°	0.5	34.51	27.70 ¹
- 12 midn.	74°11' N	0	0.3	34.60	27.78 ¹	- 10 -		0	0.4		
- 12 -	3°17' W	5°	0.5	34.59	27.77	- 10 -		3°	0.4	34.45	27.66
- 12 -		10°	0.5	34.57	27.75	- 12 midn.	74°14' N	0	0.3	34.41	27.63 ¹
23, 2 a. m.		0	0.7	34.55	27.77 ¹	- 12 -	2°00' W	5°	0.3	34.43	27.64 ¹
- 2 -		5°	0.8	34.49	27.67	25, 2 a. m.		0	0.2		
- 4 -		0	0.7	34.52	27.70 ¹	- 2 -		4°	0.3	34.43	27.65 ¹
- 4 -		5°	0.7	34.54	27.71	- 4 -		0	0.2		
- 6 -	74°11' N	0	0.6	34.57	27.74 ²	- 4 -		5°	0.3	34.13	27.40 ⁴
- 6 -	3°16' W	5°	0.6	34.55	27.73	- 4 -		0	0.2	34.13	27.41
- 6 -		10°	0.7	34.56	27.77	- 6 -		5°	0.4	34.11	27.39 ⁴
- 8 -	2.0° SW 2	0	0.6	34.38	27.60 ²	- 8 -	0.5° WSW 1	0	0.4		
- 8 -		5°	0.7	34.34	27.56 ²	- 8 -		5°	0.5	34.09	27.36 ⁴
- 10 -		0	0.7	34.37	27.58	- 10 -		0	0.4		

¹ Along ice-edge. Sea light green. ² In open sea. Sea light green. ³ Amongst scattered ice-floes. Sea light green. ⁴ Along ice-edge. Sea light blue.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
June 1901		M.	° C.	‰		June 1901		M.	° C.	‰	
25, 10 a. m.		5*	0.5	34.14	27.41	27, 12 midn.	74°48' N 4°00' W	0	0.8	34.05	27.41
- 12 noon	74°10' N 1°14' W	0	0.6	34.12	27.38 ¹	- 12 -		5*	0.6	34.24	27.48
- 2 p. m.		0	1.0		1	- 12 -		10*	0.3	34.29	27.53
- 12 midn.	74°20' N 1°50' W	0	0.8	34.14	27.39 ¹	28, 2 a. m.		0	1.0	34.17	27.40 ¹
26, 2 a. m.		0	0.7		1	- 4 -		0	1.0		3
- 2 -		5*	0.8	34.13	27.39 ¹	- 4 -		5*	0.7	34.37	27.58
- 4 -		0	0.8		1	- 6 -	74°56' N 4°42' W	0	0.3	33.73	27.89 ³
- 4 -		5*	0.7	31.14	27.40	- 6 -		5*	0.4	34.05	27.34 ³
- 6 -	74°25' N 2°10' W	0	0.7	34.10	27.36 ¹	- 8 -	1.5° W 1	0	0.8		3
- 6 -		5*	0.7	34.09	27.35	- 8 -		5*	0.7	34.06	27.33 ³
- 6 -		10*	0.6	34.06	27.34 ¹	- 10 -		0	0.4	33.74	27.09 ³
- 8 -	2.8° NW 0.5	0	0.9		1	- 12 -	74°58' N 4°56' W	0	0.8	33.93	27.20
- 8 -		5*	0.5	34.09	27.36 ¹	- 12 -		5*	0.9	33.92	27.20
- 10 -		0	0.9		1	- 12 -		10*		34.92	3
- 10 -		5*	0.6	34.06	27.34	- 2 p. m.		0	0.6		3
- 12 noon	74°30' N 2°31' W	0	0.9	34.37	27.57 ¹	- 2 -		3*		34.04	3
- 2 p. m.		0	1.67		1	- 4 -		0	0.4		3
- 2 -		5*	1.64	34.35	27.51 ¹	- 4 -		3*	0.5	33.84	27.16
- 2 -		23*	0.2	34.49	27.70 ¹	- 6 -	74°54' N 5°15' W	0	0.6	34.10	27.37 ³
- 4 -		0	0.8		1	- 6 -		5*	0.7	34.08	27.35
- 4 -		5*	0.8	34.52	27.69	- 6 -		10*	0.7		3
- 6 -	74°35' N 3°00' W	0	1.0	34.34	27.54 ¹	- 8 -	1.5° SW 1.5	0	0.5		3
- 6 -		5*	1.0	34.33	27.52 ²	- 8 -		3*	0.6	33.69	27.04 ³
- 6 -		10*	1.0	34.34	27.54 ²	- 10 -		0	1.0	33.93	27.20
- 8 -	2.0° SW 0.5	0	0.8		1	- 12 -	74°50' N 5°30' W	0	0.7	33.71	27.05 ³
- 8 -		5*	0.9	34.32	27.53	29, 2 a. m.		0	0.7	33.73	27.06 ³
- 10 -		0	0.9		1	- 4 -		0	0.3	33.81	27.15 ³
- 10 -		5*	0.8	34.34	27.52	- 6 -	74°46' N 5°45' W	0	0.4	34.27	27.52 ³
- 12 midn.	74°40' N 3°20' W	0	0.8	34.27	27.59	- 8 -	1.0° WSW 1	0	0.4		3
- 12 -		5*	1.0	34.34	27.54	- 8 -		5*	0.5	34.01	27.30
- 12 -		10*	0.5	34.32	27.55	- 10 -		5*	0.6	33.82	27.15
27, 2 a. m.		0	0.9		1	- 10 -		10*	0.4	33.86	27.18 ³
- 2 -		5*	0.8	34.35	27.56	- 10 -		0	0.4	33.86	27.18 ³
- 4 -		0	0.8		1	- 12 -	74°42' N 6°00' W	0	0.4		3
- 4 -		5*	0.9	34.33	27.53	- 12 -		4*	0.6	34.82	27.95 ³
- 6 -	74°45' N 3°40' W	0	0.8	34.19	27.43	- 12 -		0	0.4		3
- 6 -		5*	0.8	34.26	27.48	- 2 p. m.		5*	0.8	34.75	27.88 ³
- 6 -		10*	0.9	34.28	27.50	- 2 -		0	0.5	33.75	27.09
- 8 -	-1.5° N 0.5	0	0.8		1	- 4 -		0	0.5	33.83	27.15
- 8 -		5*	0.9	34.32	27.53	- 4 -		5	0.6	33.83	27.16
- 10 -		0	0.9		1	- 4 -		10*	0.4	33.83	27.16
- 12 noon	74°48' N 4°00' W	0	1.0		1	- 4 -		15*	0.4	34.06	27.35
- 2 p. m.	74°50' N 4°4' W	0	1.2		1	- 4 -		20*	0.4	34.14	27.42
- 4 -		0	1.0		1	- 4 -		25*	0.4	34.29	27.53 ³
- 6 -	74°52' N 4°14' W	0	1.0		1	- 8 -	74°41' N 5°51' W	0	0.4		3
- 8 -	-0.2° WNW 0.5	0	1.0		1	- 8 -	2.0° W 0.5	5*	0.6	33.84	27.16
- 8 -		5*	0.8	34.41	27.60	- 12 midn.	74°40' N 5°44' W	0	0.4	33.72	27.08 ³
- 10 -		0	1.0	34.07	27.32 ¹	30, 2 a. m.		0	0.4		4
						- 2 -		5*	0.7	33.73	27.06

¹ Along ice-edge. Sea light blue. ² The water is very clear, and the water-bottle is very distinctly visible at a depth of 10 metres. ³ Through slack ice. Sea light blue. ⁴ Sea light green. Through slack ice.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
June 1901		M.	° C.	‰	1	July 1901		M.	° C.	‰	
30, 4 a. m.		0	0.5			2, 4 a. m.		0	1.2	34.41	26.78 ⁴
4 -		5*	0.7	33.64	26.99 ²	6 -	74°4' N	0	1.3	34.57	26.90 ⁴
6 -	74°39' N	0	0.4	33.69	27.05	8 -	6°19' W	0	1.5	33.94	27.18 ⁴
6 -	5°37' W	5*	0.2	33.69	27.06	10 -	1.7° SW 2	0	1.1	33.97	27.24 ⁴
6 -		10*	0.2	33.71	27.08 ²	12 noon	73°55' N	0	1.3	34.22	27.42 ⁴
8 -	-1.0° N 1	0	0.3				6°40' W	0	1.2	34.08	27.31 ⁴
8 -		5*	0.6	33.69	27.04 ²	1 p. m.		5*	1.5	34.11	27.32 ⁴
10 -		0	0.7			2 -		0	1.2		
10 -		5*	0.6	33.69	27.04	4 -		0	1.2	33.84	27.12 ³
12 noon	74°35' N	0	0.6	33.49	26.88 ²	5 -	73°54' N	0	0.8	33.69	27.03 ³
12 -	5°30' W	5*	0.7	33.51	26.89	8 -	6°17' W	0	0.5	33.41	26.82 ³
12 -		10*	0.6	33.75	27.09 ²	9 -	2.5° SWbW 2	0	0.3	33.40	26.82 ³
2 p. m.		0	0.7			10 -		0	0.8	33.50	26.88 ³
2 -		3*	0.6	33.54	26.92 ²	10 -		0	0.9 ³		
4 -		0	0.6			11 -		0	0.2	33.22	26.69 ³
4 -		5*	0.6	33.49	26.88	12 midn.	73°53' N	0	0.2		
6 -	74°36' N	0	0.9	33.65	26.98 ²		9°13' W	0	0.8	33.41	26.81 ⁵
6 -	5°28' W	5*	0.9	33.83	27.13	3, 2 a. m.		0	0.7		
6 -		10*	0.8	33.96	27.25 ²	4 -		0	0.6	33.45	26.84 ³
8 -	-0.1 NW 0.5	0	0.9			6 -	73°51' N	0	0.6	33.45	26.84 ³
8 -		5*	0.9	33.75	27.07 ²	8 -	5°30' W	0	0.2	33.43	26.85 ³
10 -		0	0.8	33.56	26.92 ²	10 -	2.1° WSW 1	0	0.2	33.36	26.79 ³
10 -		5*	0.7	33.83	27.14	12 noon	73°50' N	0	0.9	33.53	26.89 ³
10 -		10*	0.3	33.88	26.86		5°10' W	0	1.0	33.78	27.09 ³
10 -		15*	0.1	33.97	27.29	2 p. m.		0	1.0	33.67	26.96 ⁴
10 -		20*	0.0	34.00	27.32	4 -		0	1.0		
10 -	74°34' N	25*	-0.4	34.16	27.47	6 -	73°45' N	0	0.6	33.52	26.90 ⁴
	5°25' W						5°12' W	0	0.6		
July 1901					2	8 -	0° W 0.5	0	0.8		
1, 4 a. m.		0	0.9			8 -		5*	0.6	33.55	26.93 ⁴
4 -		5*	0.9	33.82	27.13	10 -		0	1.0		
6 -	74°32' N	0	1.0	33.69	27.01 ²	10 -		5*	1.0	33.55	26.90
6 -	5°22' W	5*	0.9	33.78	27.10	12 midn.	73°40' N	0	0.9	33.59	26.95 ⁴
6 -		10*	0.8	33.87	27.18 ²		5°14' W	5*	0.9	33.57	26.92
8 -	1.0° SW 1	0	1.0			12 -		10*	0.9	33.59	26.95
8 -		5*	1.0	33.87	27.16 ²	12 -		15*	0.2	33.88	27.21
10 -		0	0.9	33.71	27.04 ²	12 -		20*	0.2	33.90	27.23
12 noon	74°30' N	0	0.9	33.69	27.02 ²	12 -		25*	-0.2	34.07	27.39 ⁴
	5°19' W	0	0.9			4, 2 a. m.		0	0.8		
2 p. m.		0	1.1					5*	0.7	33.89	27.19 ⁴
2 -		4*	1.3	33.87	27.15 ³	4 -		0	0.8		
4 -		0	1.3			4 -		5*	0.6	33.49	26.88
4 -		5*	1.3	33.80			73°35' N	0	0.8	33.57	26.93 ⁴
6 -	74°22' N	0	1.3	33.73		6 -	5°17' W	5*	0.7	33.58	26.95
6 -	5°39' W	0	1.2			6 -		10*	0.7	33.58	26.95 ⁴
8 -	2.2° S 1.5	0	1.3	33.79		8 -	0.5° S 0.5	0	1.1	33.55	26.90
8 -		5*	1.3			8 -		5*	1.0	33.55	26.90
10 -		0	1.3			8 -		10*	1.0	33.58	26.93 ⁴
10 -		3*	1.4	33.96	27.21	10 -		0	0.9		
12 -	74°13' N	0	1.1			10 -		5*	1.0	33.42	26.80
	5°59' W	0	0.7	33.48	26.86	12 noon	73°29' N	0	1.1	33.50	26.86 ⁶
2, 2 a. m.		0	0.7				5°20' W				

¹ Sea light green. Through slack ice. ² Sea somewhat darker green. Through slack ice. ³ Through slack ice. Sea green. ⁴ Along the ice-edge. Sea green. ⁵ The temperatures from July 2, 12 midnight, and July 3, 2 a. m., are taken during a very slow drift. ⁶ The temperature at 0 metres was at 12 noon determined with the Richter thermometer to be 1.00° C.

Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
July 1901		M.	° C.	‰		July 1901		M.	° C.	‰	
4, 12 noon		5*	1.2	33.50	26.85	7, 2 p. m.		0	2.2	34.56	27.61 ³
- 12 -		10*	1.0	33.57	26.91	- 4 p. m.		0	2.2	34.53	27.60 ³
- 2 p. m.		0	1.2		1	- 6 -	73°59' N	0	2.2	34.53	27.60 ⁴
- 2 -		5*	1.2	33.51	26.86	- 8 -	3°12' W	0	2.0	34.44	27.55 ⁴
- 4 -		0	1.0		1	- 10 -	28° NW 0.5	0	2.2	34.43	27.52 ⁴
- 4 -		5*	1.0			- 12 midn.	74°1' N	0	2.1	34.34	27.46 ⁴
- 6 -	73°18' N	0	1.0		1		3°24' W	0	2.2	34.34	27.45 ⁴
- 8 -	5°28' W	0	0.8		1	8, 2 a. m.		0	2.0	34.34	27.47 ⁴
- 8 -	18 SW 0.5	5*	0.6		1	- 4 -		5*	2.0	34.34	27.47
- 10 -		0	0.8		1	- 6 -	74°3' N	0	2.0	34.35	27.48 ⁴
- 12 midn.		0	-0.1		1	- 8 -	3°36' W	5*	1.9	34.38	27.51 ⁴
- 12 -		5*	0.7			- 8 -	14° W 0.5	0	2.2	34.44	27.54 ⁴
5, 2 a. m.	73°30' N	0	0.9	33.33	26.73 ²	- 10 -		5*	2.0	34.44	27.54 ⁴
- 4 -	5°18' W	0	0.7	33.23	26.66 ²	- 12 noon	74°4' N	0	2.3		
- 6 -	73°31' N	0	0.9	33.49	26.86 ²		3°48' W	0	2.3		
- 8 -	5°17' W	0	0.5	33.44	26.84 ²	- 12 noon	74°4' N	0	2.8	34.17	27.26 ⁴
- 10 -	04° W 0.5	0	1.5	33.38	26.73 ²		3°50' W	0	2.3	34.17	27.26 ⁴
- 12 noon	73°32' N	0	1.8	33.49	26.80 ²	- 12 -		5*	2.3	34.41	27.50
- 2 p. m.	5°16' W	0	1.7	33.22	26.60 ²	- 12 -		10*	2.3	34.41	27.50 ⁴
- 4 -		0	1.2		2	- 2 p. m.		0	2.8		
- 4 -		5*	1.2	33.58	26.92	- 2 -		5*	2.4	34.08	27.23 ⁴
- 6 -	73°36' N	0	1.2	33.61	26.94 ²	- 4 -		0	2.2		
- 6 -	5°00' W	0	1.2	33.61	26.94 ²	- 4 -		5*	2.2	33.71	26.95
- 6 -		5*	1.3	33.66	26.96	- 6 -	74°6' N	0	1.2	33.14	26.56 ²
- 6 -		10*	1.3	33.81	27.09 ²	- 8 -	4°11' W	0	1.0		
- 8 -	2.1° SSE 0.5	0	2.3		2	- 8 -	1.3° E 1	5*	1.0	32.96	26.42 ²
- 8 -		5*	1.5	33.90	27.15 ²	- 10 -		0	1.8		
- 10 -		0	2.5	34.12	27.25 ²	- 10 -		4*	1.8	33.49	26.80 ⁴
- 12 midn.	73°41' N	0	1.2	33.31	26.70 ²	- 12 midn.	74°7' N	0	2.0	33.56	26.83 ⁴
6, 2 a. m.	4°44' W	0	1.1	33.31	26.71 ²	- 12 -	4°34' W	0	2.0	33.54	26.82 ⁴
- 4 -		0	1.2	33.33	26.71 ²	9, 2 a. m.		4*	2.0	33.52	26.80 ⁴
- 6 -		0	0.7	32.96	26.45 ²	- 2 -		0	2.0		
- 8 -	3.0° SW 1	0	0.7	33.40	26.80 ²	- 4 -		5*	2.0	33.52	26.80 ⁴
- 10 -		0	1.4	33.56	26.88 ³	- 6 -	74°8' N	0	2.0	33.65	26.90 ⁴
- 12 noon	73°50' N	0	1.9	33.51	26.81 ³	- 8 -	4°57' W	0	1.9	33.40	26.72 ⁴
- 2 p. m.	4°10' W	0	1.3	33.62	26.94 ³	- 10 -	1.8° N 1.5	0	1.5		
- 4 -		0	1.1	33.62	26.96 ³	- 10 -		5*	1.5	33.56	26.87
- 6 -	73°52' N	0	1.2	33.76	27.06 ³	- 12 noon	74°9' N	0	2.0	33.86	27.07 ²
- 8 -	3°53' W	0	2.0	34.40	27.51 ³		5°20' W	0	2.3	34.23	27.36 ²
- 10 -	3.0° WSW 1	0	1.6	34.19	27.38 ³	- 2 p. m.		5*	2.3	34.23	27.36
- 12 midn.	73°54' N	0	1.8	34.23	27.40 ³	- 2 -		10*	2.3	34.24	27.37 ²
7, 2 a. m.	3°35' W	0	1.6	34.28	27.45 ³	- 4 -		0	2.2		
- 4 -		0	1.6	34.22	27.39 ³	- 4 -		5*	2.1	34.23	27.37 ²
- 6 -	73°56' N	0	1.4	34.17	27.38 ³	- 6 -		0	1.2	33.44	26.80 ²
- 8 -	3°17' W	0	2.0	34.30	27.43 ³	- 8 -	74°10' N	0	0.9		
- 10 -	3°5° S 1	0	1.9	34.24	27.40 ³	- 8 -	5°20' W	5*	0.9	33.20	26.62 ⁴
- 12 noon	73°58' N	0	1.8	34.25	27.41 ³	- 10 -	1.4° WNW 2	0	1.4		
	3°00' W	0	1.8	34.25	27.41 ³			5*	1.3	33.39	26.66

¹ Along ice-edge. Sea green. ² Along ice-edge. Sea light green. ³ The sea has a marked light green colour. Great numbers of crustaceans in the sea. ⁴ In open sea colour light green.

Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
July 1901		M.	C.	‰		July 1901		M.	° C.	‰	
0, 12 midn.	74°12' N 5°21' W	0	0.6	32.96	26.45 ¹	12, 10 a. m.		5'	1.3	32.93	26.38
- 12 -		5'	0.4	32.96	26.46 ²	- 12 noon	74°30' N 6°29' W	0	3.0		5
10, 2 a. m.		0	1.2			- 12 -		5'	2.7	34.12	27.24 ⁵
- 2 -		5'	1.2	33.31	26.70 ¹	- 2 p. m.		0	2.8		5
- 4 -		0	1.0	33.17	26.59 ¹	- 2 -		5'	2.8	34.22	27.30 ⁵
- 6 -	74°14' N 5°22' W	0	0.8	33.02	26.48 ¹	- 4 -		0	2.8	33.99	27.12 ⁵
- 8 -	0.9° WNW 1	0	0.5	32.84	26.37 ¹	- 6 -	74°34' N 6°27' W	0	2.5	33.79	27.00 ⁵
- 10 -		0	1.0	33.13	26.57 ¹	- 8 -	2.1° SE 1	0	2.3	33.23	26.55 ⁵
- 12 noon	74°15' N 5°23' W	0	1.3	33.31	26.70 ³	- 10 -		0	0.7		6
- 12 -		5'	1.4	33.33	26.70	- 10 -		5'	0.9	32.61	26.15
- 12 -		10'	1.5	33.54	26.87 ³	- 12 midn.	74°38' N 6°25' W	0	0.2	32.23	25.89 ⁶
- 2 p. m.		0	1.0			- 12 -		5'	0.6		5
- 2 -		5'	1.2	33.19	26.61 ³	13, 2 a. m.		0	1.3	32.77	26.26 ⁵
- 4 -		0	1.0	33.18	26.61 ³	- 2 -		5'	1.5		5
- 6 -	74°19' N 5°43' W	0	0.8	33.04	26.51 ³	- 4 -		0	0.5	32.87	26.38 ⁵
- 6 -		5'	0.8	33.03	26.50 ³	- 4 -		5'	0.6	32.49	26.08 ⁵
- 8 -	0.4° WNW 1	0	0.7			- 6 -	74°41' N 6°22' W	0	0.7		5
- 8 -		5'	0.7	32.92	26.42 ³	- 8 -	1.6° Ebn 1	0	0.6	32.42	26.02 ⁵
- 10 -		0	0.4	32.73	26.27 ³	- 8 -		5'	0.7		5
- 10 -		5'	0.6	32.78	26.31	- 10 -		0	1.1	32.61	26.14 ⁵
- 10 -		10'	0.4	32.82	26.35	- 10 -		5'	1.2	32.53	26.07 ⁵
- 10 -		15'	0.2	33.60	26.99	- 12 noon	74°45' N 6°20' W	0	1.0	32.56	26.11 ⁵
- 10 -		20'	0.0	33.78	27.15	- 12 -		5'	1.1		5
- 10 -		25'	-0.1	33.79	27.16 ³	- 12 p. m.		0	1.8		5
- 12 midn.	74°23' N 6°3' W	0	0.4			- 2 -		5'	1.9	33.13	26.51 ⁵
11, 2 a. m.		0	0.5			- 4 -		0	1.5		5
- 2 -		5'	0.6	32.92	26.42 ³	- 4 -		5'		32.95	
- 4 -		0	0.9	33.13	26.57 ³	- 6 -	74°56' N 5°00' W	0	1.3	33.12	26.54 ⁵
- 6 -	74°26' N 6°24' W	0	1.2	33.22	26.63 ³	- 6 -		5'		32.95	5
- 8 -	0.2° SSW 0.5	0	1.8	33.15	26.54 ³	- 8 -	1.2 NNE 1.5	0	0.5	32.58	26.16 ⁵
- 10 -		0	1.0	32.75	26.27 ³	- 10 -		0	1.4	33.24	26.63 ⁶
- 12 noon	74°30' N 6°55' W	0	0.6			- 12 midn.	75°7' N 3°40' W	0	1.0	32.87	26.36 ⁶
- 12 -		5'	1.0	32.68	26.21 ³	14, 2 a. m.		0	0.6	32.59	26.16 ⁶
- 2 p. m.		0	1.0			- 4 -		0	1.0		6
- 2 -		5'	1.0	32.73	26.24 ⁴	- 4 -		5'	0.6	33.24	26.68 ⁶
- 4 -		0	0.5			- 6 -	75°18' N 2°20' W	0	0.7		5
- 4 -		5'	0.8	32.49	26.01 ⁴	- 6 -		5'	0.7	32.85	26.36 ⁵
- 6 -	74°30' N 6°47' W	0	0.1	32.21	25.58 ⁴	- 8 -	1.0° NNE 1.5	0	1.3		7
- 8 -	0.5° SW 0.5	0	0.0			- 8 -		5'	1.2	33.91	27.18 ⁷
- 10 -		0	-0.1			- 10 -		0	1.9		7
- 12 midn.		0	0.0			- 10 -		5'	2.0	34.34	27.47 ⁷
12, 2 a. m.		0	0.0			- 12 noon	75°30' N 1°2' W	0	2.3	34.45	27.53 ⁷
- 4 -		0	-0.2			- 12 -		5'	2.3	34.34	27.45 ¹
- 4 -		5'	-0.2	32.26	25.92 ⁴	- 2 p. m.		0	2.4		7
- 6 -	74°30' N 6°39' W	0	0.2			- 2 -		5'	2.4	34.23	27.35 ⁷
- 6 -		5'	0.2	32.20	25.86 ⁴	- 4 -		0	2.3		7
- 8 -	0.5 SSW 0.5	0	0.6			- 4 -		5'	2.4	34.33	27.32 ⁷
- 8 -		5'	0.6	32.53	26.11 ⁴	- 6 -	75°41' N 0°5' W	0	2.0	34.45	27.53 ⁷
- 10 -		0	1.1								

¹ Along ice-edge. Sea light green. ² In open sea, colour light green. ³ In slack ice. Sea light green.
⁴ In slack ice. Sea green. ⁵ In open sea, colour dark green. ⁶ Along ice-edge. Sea dark green. ⁷ Sea dark blue.

Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
July 1901		M.	° C.	‰		July 1901		M.	° C.	‰	
14, 6 p. m.		5*	2.4	34.43	27.51 ¹	17, 2 p. m.		0	4.0	34.70	27.57 ⁴
- 8 -	2.3° NNE 1	0	2.3			- 4 -		0	1.2	33.40	26.77 ⁴
- 8 -		5*	2.6	34.52	27.55 ¹	- 6 -	79°22' N	0	3.4	34.71	27.64 ⁵
- 10 -		0	2.3			- 8 -	10°10' E	0	2.5	34.50	27.63 ⁵
- 10 -		5*	2.4			- 10 -	4.0° S 1.5	0	3.1	34.16	27.23 ⁵
- 12 midn.	75°52' N	0	2.1	34.66	72.71 ¹	- 12 midn.	79°43' N	0	2.8	34.10	27.21 ⁵
15, 2 a. m.	0°52' E	0	2.3	34.44	27.53 ²	- 12 -	10°15' E	0	2.9	34.13	27.22 ⁵
- 2 -		5*	2.3			- 12 -		5*	2.9	34.13	27.22 ⁵
- 4 -		0	2.1			18, 2 a. m.		0	2.9	34.37	27.41 ⁵
- 4 -		5*	2.2	34.68	27.72	- 2 -		0	2.2	34.34	27.45
- 6 -	75°3' N	0	1.8	34.67	27.75	- 4 -		5*	2.3	34.34	27.45
- 6 -	1°49' E	5*	1.9			- 4 -		0	2.2	34.05	27.22 ⁵
- 8 -		0	1.9		3	- 6 -	1 mile WSW from NW point of Danish Island	0	2.2	34.05	27.22 ⁵
- 8 -	1.5° N 1.5	5*	1.8		3	- 6 -		5*	2.4	34.21	27.33
- 10 -		0	2.6			- 6 -		10*	2.4	34.29	27.39 ⁶
- 12 noon	76°15' N	0	1.0	32.59	26.14 ³	- 8 -		0	2.2	34.22	27.33 ⁶
- 2 p. m.	2°48' E	0	1.8	32.90	26.36 ⁴	- 8 -	4.2° N 0.5	5*	2.4	34.22	27.33 ⁶
- 4 -		0	1.0	33.12	26.56 ⁴	- 10 -		0	2.6	33.97	27.13 ⁶
- 6 -	76°38' N	0	1.9	34.04	27.23 ⁴	- 12 noon	Kobbe-Bay	0	2.5	33.98	27.14 ⁶
- 6 -	4°46' E	5*	1.9	34.14	27.32	- 2 p. m.		0	4.0	33.49	26.61 ⁶
- 6 -		10*	1.9	34.51	27.61	- 4 -		0	3.1	33.33	26.57 ⁶
- 6 -		15*	1.7	34.46	27.58	- 6 -		0	3.2	32.82	26.15 ⁶
- 6 -		20*	1.6	34.44	27.58	- 8 -	5.5° Calm	0	3.0	33.33	26.57 ⁶
- 6 -		25*	1.6	34.40	27.54 ⁴	- 10 -		0	2.8		
- 8 -	1.3° NW 1.5	0	1.8	33.81	27.06 ⁴	- 12 midn.		0	2.5	34.14	27.27 ⁶
- 10 -		0	2.8	34.52	27.53 ⁴	- 12 -		1*	2.8	34.15	27.26
- 12 midn.	77°1' N	0	2.8	34.62	27.61 ⁴	- 12 -		5*	2.8	34.22	27.30 ⁶
16, 2 a. m.	6°44' E	0	2.7	34.62	27.62 ⁴	19, 2 a. m.		0	2.4		
- 4 -		0	2.6	34.60	27.61 ⁴	- 4 -		0	2.4		
- 6 -	77°25' N	0	2.7	34.59	27.60 ⁴	- 6 -		0	2.4		
- 8 -	8°42' E	0	2.8	34.59	27.59 ⁴	- 8 -	7.0° S 0.5	0	2.5		
- 10 -	3.0° WSW 1	0	3.2	34.66	27.62 ⁴	- 10 -		0	4.0		
- 12 noon	77°49' N	0	3.8	34.77	27.65 ⁴	- 12 noon		0	3.8		
- 2 p. m.	10°40' E	0	4.2	34.83	27.67 ⁴	- 12 -		5*	3.2	34.14	27.21 ⁶
- 4 -		0	5.2	34.97	27.66 ⁴	- 2 p. m.		0	3.0		
- 6 -	78°6' N	0	4.8	34.90	27.64 ⁴	- 4 -		0	4.0		
- 8 -	10°30' E	0	4.0	34.67	27.55 ⁴	- 6 -	5.0° NW 0.5	0	4.0		
- 10 -	3.0° SSW 2	0	3.0	34.44	27.42 ⁴	- 8 -		0	2.2	34.07	27.24 ⁷
- 12 midn.	78°23' N	0	2.0	34.21	27.23 ⁴	- 10 -		0	2.1		
17, 2 a. m.	10°20' E	0	2.4	34.20	27.32 ⁴	20, 2 a. m.		0	2.0		
- 4 -		0	3.7	34.52	27.46 ⁴	- 4 -		0	2.0		
- 6 -	78°40' N	0	4.8	34.86	27.62 ⁴	- 6 -	4.0° N 0.5	0	2.0		
- 8 -	10°10' E	0	4.6	34.50	27.35 ⁴	- 8 -		0	2.0		
- 12 -	4.5° S 1.5	0	3.5	34.61	27.54 ⁴	- 10 -		0	2.2		
- 12 noon	78°57' N	0	3.8	34.67	27.57 ⁴	- 12 midn.	4.2 NNE 0.5	0	2.2		
	10°00' E	0						0	2.2		
								0	2.2		

¹ Sea dark blue. ² At 1 a. m. the sea suddenly changed from dark blue to a dirty-green colour. At the same time there was a heavy swell, and the sea was very rich in plankton. After 2-3 hours the swell again calmed down. ³ In open sea, colour dark, dark blue. ⁴ Sea green. ⁵ In open sea, colour green. ⁶ At anchor in Kobbe-Bay, Spitsbergen. ⁷ At anchor in Danish Gate, Spitsbergen.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
July 1901		M.	° C.	‰		July 1901		M.	° C.	‰	
21, 2 a. m.		0	22		1	25, 10 p. m.		0	28		1
- 4 -		0	22		1	- 12 midn.		0	29		1
- 6 -		0	22		1	26, 2 a. m.		0	29		1
- 8 -	50° SSW 1	0	23		1	- 4 -		0	28		1
- 10 -		0	24		1	- 6 -		0	28		1
- 12 noon		0	23		1	- 8 -	18° WNW 0.5	0	28		1
- 2 p. m.		0	23		1	- 10 -		0	28		1
- 4 -		0	23		1	- 12 noon		0	28		1
- 6 -		0	26		1	- 2 -		0	28		1
- 8 -	63° SSW 0.5	0	24		1	- 4 -		0	28		1
- 10 -		0	25		1	- 6 -		0	28		1
- 12 midn.		0	26		1	- 8 -	25° NW 0.5	0	28		1
22, 2 a. m.		0	28		1	- 10 -		0	27		1
- 4 -		0	27		1	- 12 midn.		0	28		1
- 6 -		0	27		1	27, 2 a. m.		0	28		1
- 8 -	58° W 0.5	0	28		1	- 4 -		0	28		1
- 10 -		0	28		1	- 6 -		0	28		1
- 12 noon		0	30		1	- 8 -	19° SW 2	0	28		1
- 2 p. m.		0	29		1	- 10 -		0	28		1
- 4 -		0	29		1	- 12 noon		0	28		1
- 6 -		0	29		1	- 2 p. m.		0	29		1
- 8 -	40° W 0.5	0	29		1	- 4 -		0	29		1
- 10 -		0	29		1	- 6 -		0	28		1
- 12 midn.		0	29		1	- 8 -	34° WSW 1	0	27		1
23, 2 a. m.		0	29		1	- 10 -		0	28		1
- 4 -		0	29		1	- 12 mtdn.		0	28		1
- 6 -		0	29		1	28, 2 a. m.		0	29		1
- 8 -	43 SW 1	0	29		2	- 4 -		0	29		1
- 10 -		0	28			- 6 -		0	28		1
- 12 noon		0	22			- 8 -	19° NE 0.5	0	28		1
- 2 p. m.		0	09		3	- 10 -		0	29		1
- 4 -		0	05		3	- 12 noon		0	29		1
- 6 -		0	06		3	- 2 p. m.		0	29		1
- 8 -	20° W 1.5	0	07		3	- 4 -		0	29		1
- 10 -		0	08		3	- 6 -		0	29		1
- 12 midn.		0	08		3	- 8 -	27° ENE 0.5	0	29		1
24, 2 a. m.		0	08		3	- 10 -		0	29		1
- 4 -		0	07		3	- 12 midn.		0	30		1
- 6 -		0	07		3	29, 2 a. m.		0	29		1
- 8 -	15° W 1	0	08		3	- 4 -		0	28		1
- 10 -		0	09		3	- 6 -		0	29		1
- 12 noon		0	07		3	- 8 -	35° SSW 1	0	29		1
- 2 p. m.		0	08		3	- 10 -		0	29		1
- 4 -		0	09		3	- 12 noon		0	29		1
- 6 -		0	09		3	- 2 p. m.		0	30		1
- 8 -	20° W 1	0	09		3	- 4 -		0	30		1
- 10 -		0	08		3	- 6 -		0	29		1
- 12 midn.		0	08		3	- 8 -	23 NEbE 1	0	28		1
25, 2 a. m.		0	09		3	- 10 -		0	28		1
- 4 -		0	09		3	- 12 midn.		0	28		1
- 6 -		0	09		3	30, 2 a. m.		0	28		1
- 8 -	25° W 1	0	10		3	- 4 -		0	27		1
- 10 -		0	10		3	- 6 -		0	27		1
- 12 noon		0	15		4	- 8 -	11° ENE 2	0	27		1
- 2 p. m.		0	25			- 10 -		0	28		1
- 4 -		0	23			- 12 noon		0	28		1
- 6 -		0	23			- 2 p. m.		0	28		1
- 8 -	35° SW 0.5	0	23			- 4 -		0	28		1

¹ At anchor in Danish Gate, Spitsbergen. ² Left Danish Gate at 9 a. m. ³ At anchor near Norwegian Island. ⁴ Left Norwegian Island.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
July 1901		M.	° C.	‰		August 1901		M.	° C.	‰	
30, 6 p. m.	-0°1' NE 1	0	26		1	4, 10 a. m.	5°0' Stille 0-0	0	3.3		1
- 8 -		0	27		1	- 12 noon		0	3.2		1
- 10 -		0	28		1	- 2 p. m.		0	3.0		1
- 12 midn.		0	28		1	- 4 -		0	3.1		2
31, 2 a. m.		0	28		1	- 6 -		0	3.1		3
- 4 -	0°3' NW 0.5	0	28		1	- 8 -	3°0' WSW 1	0	3.2		3
- 6 -		0	28		1	- 8 -		5*	2.8	34.08	27.20
- 8 -		0	28		1	- 10 -		0	3.1		3
- 10 -		0	28		1	- 10 -		5*	3.3	33.91	27.01
- 12 noon		0	28		1	- 12 midn.	{ 4 miles SE of from Magda- lena Hook	0	3.3	34.06	27.13
- 2 p. m.	4°0' SW 1.5	0	28		1	- 12 -		5*	3.3	34.26	27.29
- 4 -		0	28		1	- 12 -		10*	3.7	34.18	27.19
- 6 -		0	28		1	5, 2 a. m.		0	3.1		3
- 8 -		0	28		1	- 2 -		5*	3.1	34.54	27.52
- 10 -		0	28		1	- 4 -	{ 79°39' N 10°5' E	0	3.2		3
- 12 midn.		0	28		1	- 4 -		5*	3.2	34.59	27.55
August 1901						- 6 -		0	3.8		3
1, 2 a. m.	3°0' SW 2	0	28		1	- 6 -		5*	3.4	34.66	27.60
- 4 -		0	28		1	- 8 -	2°0' NNW 1	0	4.2		3
- 6 -		0	28		1	- 8 -	{ 79°32' N 9°15' E	5*	4.2	34.52	27.50
- 8 -		0	28		1	- 10 -		0	4.6	34.75	27.55
- 10 -		0	28		1	- 12 noon	{ 79°59' E 9°30' E	0	4.4	34.65	27.49
- 12 noon	3°8' SW 2	0	28		1	- 2 p. m.		0	4.4	34.79	27.52
- 2 p. m.		0	28		1	- 4 -	{ Middle Hook Prince Charles Foreland 8 miles off in E	0	4.9	34.84	27.59
- 4 -		0	28		1	- 6 -		0	4.1	34.09	27.07
- 6 -		0	28		1	- 8 -	{ 78°16' N 10°45' E	0	4.0	33.86	26.91
- 8 -		0	28		1	- 10 -	4°3' NNE 1	0	4.3		3
- 10 -	1°2' W 0.5	0	28		1	- 10 -		5*	4.6	33.58	26.62
- 12 noon		0	28		1	- 12 midn.	{ 78°11' N 11°20' E	0	4.7	34.02	26.96
- 2 p. m.		0	28		1	- 12 -		5*		34.25	
- 4 -		0	28		1	6, 2 a. m.		0	4.3	33.09	26.26
- 6 -		0	28		1	- 4 -	{ 77°48' N 12°8' E	0	2.8	34.36	27.42
- 8 -	2° WSW 1	0	28		1	- 6 -		0	4.0	33.75	26.82
- 10 -		0	28		1	- 8 -	{ 77°35' N 10°45' E	0	4.0	34.43	27.47
- 12 midn.		0	28		1	- 10 -	3°0' NE E 3	0	3.9	34.29	27.25
3, 2 a. m.		0	28		1	- 12 noon	{ 77°20' N 13°40' E	0	2.9	33.74	26.91
- 4 -		0	3.1		1	- 2 p. m.		0	3.2	34.23	27.28
- 6 -	2°8' NW 0.5	0	3.2		1	- 4 -	{ 76°53' N 14°50' E	0	3.4	34.24	27.27
- 8 -		0	3.0		1	- 6 -		0	2.8	34.37	27.43
- 10 -		0	3.0		1	- 8 -	{ 76°27' N 16°00' E	0	2.3	34.40	27.49
- 12 midn.		0	3.0		1	- 10 -	2°8' N 2	0	3.6	34.72	27.64
4, 2 a. m.		0	2.9		1	- 12 midn.	{ 76°13' N 16°20' E	0	2.6	34.33	27.40
- 4 -	4°0' NW 0.5	0	2.9		1	7, 2 a. m.		0	3.1	33.57	26.75
- 6 -		0	3.1		1						
- 8 -		0	3.1		1						
- 10 -	{ 79°41' N 10°43' E	0	3.1		1						
- 12 midn.		0	3.1		1						
- 2 p. m.		0	3.1		1						

¹ At anchor in Danish Gate. ² Left Danish Gate at 3 p. m. ³ Sea dark green.

Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality AirTemperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
August 1901		M.	° C.	‰		August 1901		M.	° C.	‰	
7, 4 a. m.	76°6' N 12°12' E	0	2.6	34.02	27.16 ¹	10, 10 p. m.		0	2.5		5
- 6 -		0	3.1	34.39	27.42 ¹	- 12 midn.		0	2.7		5
- 8 -	76°6' N 17°55' E	0	3.2	34.51	27.50 ¹	11, 2 a. m.		0	2.7		5
- 10 -	3.3° NW 3	0	3.2	34.17	27.23 ¹	- 4 -		0	2.2		5
- 12 noon	76°6' N 18°30' E	0	3.2	34.08	27.16 ²	- 6 -	25° WNW 1	0	2.3		5
- 12 -		5*	3.4	34.12	27.17 ³	- 8 -		0	2.4		5
- 2 p. m.		0	3.3			- 10 -		0	2.5		5
- 2 -		5*	3.5	34.04	27.09	- 12 -		0	2.8		5
- 4 -	76°48' N 19°00' E	0	3.2	33.93	27.03 ³	2 p. m.		0	3.2		5
- 6 -		0	3.0	33.94	27.04 ³	- 4 -	Sailed from Deevie Bay	0	3.6		6
- 8 -	77°10' N 20°00' E	0	2.8	33.96	27.10 ³	- 6 -	20° WNW 1	0	2.1		7
- 10 -	3.2° NW 3	0	3.2	34.04	27.12 ³	- 8 -		0	0.2	32.60	26.17 ⁷
- 12 midn.	76°57' N 21°13' E	0	3.2	33.89	27.00 ³	- 10 -		0	0.6		
8, 2 a. m.		0	2.8	34.11	27.22 ³	- 12 midn.	77°26' N 24°00' E	0	0.9	32.66	26.19 ⁷
- 4 -	77°23' N 21°5' E	0	2.5	34.01	27.16 ⁴	12, 2 a. m.		5*	1.2	32.76	26.27 ⁷
- 6 -		0	2.2	33.31	26.63 ⁴	- 4 -	77°34' N 24°22' E	0	0.9	32.81	26.32 ⁷
- 8 -	Deevie Bay 2.5° W 2.5	0	0.5	33.50	26.90 ⁴	- 6 -		0	1.0	33.08	26.53 ⁷
- 10 -		0	0.6			- 8 -	1.9° NNE 1	0	1.0	32.81	26.31 ⁷
- 10 -		5*	0.8	34.27	27.43 ⁴	- 10 -	77°36' N 24°35' E	5*	1.1	32.82	26.31 ⁷
- 12 noon		0	2.3	33.29	26.60 ⁵	- 8 -		0	1.3		
- 2 p. m.	At anchor in Deevie Bay	0	2.2			- 10 -		0	1.4	33.04	26.48 ⁸
- 4 -		0	2.2		5	- 12 noon	77°36' N 25°00' E	0	1.4	33.31	26.69
- 6 -		0	2.2		5	- 12 -		5*	1.5	33.21	26.60 ¹⁰
- 8 -	3.5 SW 0.5	0	2.2		5	- 12 -		5*	1.4		
- 10 -		0	2.4		5	- 2 p. m.		10*	1.5	33.22	26.62 ⁸
- 12 midn.		0	2.4		5	- 2 -		0	1.5		
9, 2 a. m.		0	2.3		5	- 2 p. m.		5*	1.6	33.11	26.51 ⁸
- 4 -		0	2.3		5	- 4 -	77°37' N 25°20' W	0	1.5		
- 6 -		0	2.2		5	- 6 -		5*	1.5	32.77	26.24 ⁸
- 8 -		0	2.2		5	- 6 -		0	1.7		
- 10 -	1.8° WSW 1	0	2.3		5	- 6 -		5*	1.5	32.76	26.24
- 12 noon		0	2.5		5	- 6 -		5*	1.5	32.78	26.25 ⁸
- 2 p. m.		0	2.6	33.20	26.51 ⁵	- 8 -	2.5 S 0.5	0	1.6		
- 4 -		0	2.5		5	- 8 -	77°39' N 25°40' E	5*	1.5	32.79	26.26 ⁸
- 6 -		0	2.5		5	- 10 -		0	1.5		
- 8 -	Went out from Deevie Bay	0	2.5		6	- 10 -		5*	1.6	33.27	26.64
- 10 -		0	0.7	33.31	26.73 ⁴	- 12 midn.	77°41' N 25°12' E	0	1.6	33.28	26.65 ⁸
- 12 -		0	2.3		5	13, 2 a. m.		0	1.8	32.94	26.35 ⁹
10, 2 a. m.	At anchor in Deevie Bay	0	3.0		5	- 4 -	77°52' N 25°47' E	0	1.9	33.60	26.88 ⁹
- 4 -		0	2.5		5	- 6 -		0	1.6	33.78	27.05 ⁹
- 6 -		0	2.5		5	- 8 -	1.5° SW 0.5	0	1.6		
- 8 -	3.5° SSE 1.5	0	2.3		5	- 8 -	78°4' N 23°51' E	5*	1.6	33.80	27.06
- 10 -		0	2.3		5	- 10 -		0	1.8	33.62	26.91 ⁹
- 12 noon		0	2.4		5	- 10 -		5*	1.8	33.72	26.99
- 2 p. m.		0	2.4		5	- 10 -		10*	1.9	33.78	27.03
- 4 -		0	2.5		5	- 10 -		15*	1.9	33.83	27.07
- 6 -		0	2.5		5	- 10 -		20*	1.8	33.91	27.14
- 8 -	3.0° SE 2.5	0	2.5		5	- 10 -					

¹ Sea dark green. ² Sea blue and very clear. ³ Sea dark blue. ⁴ Sea grayish-blue. ⁵ Remained in Deevie Bay. ⁶ Left Deevie Bay. ⁷ Sea grayish-green. ⁸ Sea light blue. ⁹ Sea light blue and very clear. ¹⁰ Strong current NW-SE, which seemed to change regularly.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
August 1901		M.	° C.	‰		August 1901		M.	° C.	‰	
13, 10 a. m.		25*	1.2	33.97	27.24	15, 8 a. m.	78°18' N 33°34' E	5*	0.1	33.11	26.59
- 12 noon	77°52' N 24°35' E	0	1.0	33.48	26.84 ¹	- 10 -		0	0.1		
- 2 p. m.		0	0.9	32.17	25.80 ¹	- 10 -		5*	0.2	33.16	26.64 ²
- 4 -	77°58' N 24°20' E	0	0.8			- 12 noon	78°18' N 23°34' E	0	0.2	33.08	26.57 ²
- 4 -		5*	0.8	32.14	25.78	- 12 -		5*	0.3	33.12	26.59
- 6 -		0	1.0	32.40	25.99 ¹	- 12 -		10*	0.1	33.17	26.64 ²
- 6 -		5*	1.0	32.57	26.12	- 2 p. m.		0	0.1	32.83	26.37 ²
- 6 -		10*	1.0	32.43	26.01	- 4 -		0	0.1	32.41	26.03 ³
- 8 -	78°9' N 24°00' E	0	1.0			- 6 -		0	0.2	32.01	25.71 ³
- 8 -	0.8° NW 0.5	5*	1.0	32.43	26.01 ¹	- 8 -	78°15' N 23°35' E	0	0.8	32.34	25.94 ³
- 10 -		0	1.0			- 10 -	3.8 W 0.5	0	0.7	32.44	26.03 ³
- 10 -		5*	1.0	32.69	26.22	- 12 midn.	78°18' N 22°55' E	0	0.7	32.19	25.83 ³
- 12 midn.	78°7' N 23°35' E	0	0.9	32.74	26.26 ¹	16, 2 a. m.	78°18' N 22°55' E	0	0.9	32.01	25.68 ³
- 12 -		5*	1.1	32.95	26.42	- 4 -		0	1.0		
- 12 -		10*	1.0	33.21	26.63 ¹	- 6 -		0	0.6		
14, 2 a. m.		0	1.5	33.49	26.82 ¹	- 8 -	78°18' N 22°55' E	0	0.6		
- 4 -	78°15' N 23°43' E	0	2.0	33.96	27.16 ¹	- 10 -	6.2 SW 0.5	0	0.9	32.30	25.90 ³
- 6 -		0	0.8	33.43	26.83 ¹	- 12 noon	78°24' N 23°6' E	0	0.8	32.45	26.03 ³
- 8 -	78°24' N 23°50' E	0	1.0			- 2 p. m.		0	0.7	32.48	26.06 ³
- 10 -	2.2 SW 1.5	0	2.2	33.87	27.08 ¹	- 4 -	78°21' N 23°55' E	0	-0.6	32.82	26.39 ³
- 12 noon		0	1.4	33.76	27.05 ¹	- 6 -		0	-0.4	32.68	26.28 ³
- 12 -	78°19' 25°8'	5*	1.3	33.74	27.03	- 6 -		5*	-0.4	33.24	26.73 ³
- 12 -		10*	1.3	32.78	27.07	- 8 -	3.2 SW 1	0	0.2	32.98	26.49 ³
- 12 -		15*	1.4	33.83	27.11	- 8 -	78°44' N 24°14' E	5*	0.3	33.24	26.70 ³
- 12 -		20*	1.0	34.00	27.26	- 10 -		0	0.2		
- 12 -		25*	0.7	34.09	27.35	- 10 -		5*	0.3	33.35	26.71 ³
- 2 p. m.	78°6' N 24°23' E	0	1.6	33.86	27.10 ¹	- 12 midn.	78°57' N 24°32' E	0	-0.1	32.88	26.42 ³
- 4 -		0	1.7			17, 2 a. m.	78°35' N 25°20' E	0	-0.1	32.85	26.40 ³
- 4 -		5*	1.6	33.88	27.13 ¹	- 4 -		0	0.5	33.41	26.82 ³
- 6 -		0	1.4	33.87	27.14 ¹	- 6 -		0	0.4	33.43	26.85 ⁶
- 6 -	78°21' N 23°30' E	5*	1.3	33.89	27.15	- 8 -	78°47' N 24°45' E	0	-0.2	33.12	26.62 ⁶
- 8 -		10*	1.3	33.86	27.12	- 10 -	1.0° N 1.5	0	-0.1	33.12	26.61 ⁶
- 8 -	78°23' N 33°11' E	0	1.6			- 12 noon		0	0.0	33.17	26.65 ⁶
- 10 -	1.4 NE 0.5	5*	1.5	33.59	26.91 ¹	- 12 -	79°4' N 23°52' E	5*	0.1	33.19	26.66
- 10 -		0	0.4			- 2 p. m.		0	0.7	33.29	26.71 ⁶
- 10 -		5*	0.4	33.12	26.59	- 4 -	79°3' N 22°22' E	0	0.1	32.88	26.41 ⁶
- 12 midn.	78°17' N 23°25' E	0	0.1	33.13	26.61 ²	- 6 -		0	-0.1	32.75	26.32 ⁶
- 12 -		5*	0.1	33.12	26.60	- 6 -		5*	0.0	32.78	26.34 ⁶
- 12 -		10*	0.1	33.16	26.64 ²	- 8 -	0.6° NW 0.5	0	-0.2	32.66	26.25
15, 2 a. m.		0	0.0	33.07	26.57 ²	- 8 -	78°56' N 24°32' E	5*	-0.2	32.66	26.25
- 4 -	78°15' N 23°30' E	0	0.0			- 10 -		0	0.0	32.51	26.12 ⁶
- 4 -		5*	0.1	33.08	26.57 ²	- 10 -		5*	0.1	32.82	26.36
- 6 -		0	0.1	33.12	26.60 ²	- 10 -		10*	0.0	33.32	26.78
- 6 -		5*	0.0	33.17	26.65						
- 6 -		10*	0.0	33.17	26.65 ²						
- 8 -	0.3° 2E 0.5	0	0.1								

¹ Sea light blue and very clear.² Along ice-edge.³ Through ice.⁴ At anchor off Cape Heuglin.⁵ Left Cape Heuglin at 8 a. m.⁶ Through ice. Sea blue.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
August 1901						August 1901					
17, 10 p. m.		M.	° C.	‰		19, 10 a. m.		M.	° C.	‰	
- 10 -		15.	-0.7	33.95	26.31	- 12 noon	79°1' N 25°14' E	5.	0.2	33.00	26.51
- 10 -		20.	-0.7	34.02	27.37	- 12 -		0	0.7	32.84	26.35 ¹
- 12 midn.	79°2' N 24°46' E	25.	-0.7	34.13	27.45	- 12 -		5.	0.8	33.19	26.63
- 12 -		0	0.4	32.84	26.37 ¹	- 12 -		10.	1.0	33.47	26.83 ¹
18, 2 a. m.		5.	0.1	33.21	26.67 ¹	- 2 p. m.		0	0.5		
- 4 -	78°57' N 24°32' E	0	-1.0	32.03	25.78 ¹	- 2 -		5.	1.3	33.28	26.67 ¹
- 4 -		0	-0.2			- 4 -	78°56' N 25°52' E	0	1.0		
- 4 -		5.	-0.1	32.47	26.09	- 4 -		5.	1.1	32.39	25.97 ¹
- 6 -		0	0.1	32.51	26.12 ¹	- 6 -		0	-0.2	32.20	25.88 ¹
- 6 -		5.	0.2	33.02	26.52	- 8 -	0.0° SSE 1	0	-0.5		
- 6 -		10.	0.2	33.11	26.59 ¹	- 8 -	79°00' N 26°40' E	5.	-0.8	32.34	26.01 ¹
- 8 -	1.0 NNW 0.5	0	0.5			- 10 -		0	-0.1		
- 8 -	79°3' N 24°45' E	5.	0.5	33.05	26.53 ¹	- 10 -		5.	-0.1	32.36	26.00 ²
- 10 -		0	-0.3			- 12 midn.	79°7' N 26°32' E	0	-0.7	32.04	25.78 ²
- 10 -		5.	-0.2	32.78	26.35	- 12 -		5.	0.1	33.28	26.74 ²
- 12 noon	79°3' N 24°49' E	0	0.3	32.39	26.02 ¹	20, 2 a. m.		0	0.3	32.44	26.06 ²
- 12 -		5.	0.4	32.85	26.38	- 2 -		5.	1.6	33.54	26.86 ²
- 12 -		10.	0.6	33.22	26.67	- 4 -	79°00' N 26°43' E	0	0.6		
- 12 -		15.	0.8	33.50	26.88	- 4 -		5.	0.7	32.74	26.27 ²
- 12 -		20.	-0.6	34.15	27.48	- 4 -		0	0.2	32.29	25.93 ²
- 12 -		25.	-0.6	34.18	27.50	6 6 -		5.	0.6	33.24	26.68
- 12 -		16.	1.1	33.57	26.90	- 6 -		10.	0.7	33.67	26.02 ²
- 12 -		17.	0.5	33.69	27.04 ¹	- 6 -		0	0.4		
- 12 -		18.	0.1	33.84	27.18	- 8 -	1.5° Calm				
- 12 -		19.	0.0	33.98	27.31	- 8 -	79°1' N 26°43' E	5.	0.8	33.14	26.59 ²
- 12 -		20.	-0.3	34.07	27.39	- 10 -		0	1.3		
- 12 -		25.	-0.4	34.17	27.48 ¹	- 10 -		0	1.7		
- 2 p. m.		0	0.3			- 12 noon	79°00' N 26°39' E	0	1.7		
- 2 -		5.	0.3	32.94	26.45 ²	- 2 p. m.		0	1.8		
- 4 -	79°4' N 20°55' E	0	0.0			- 4 -	79°10' N 27°25' E	0	1.2		
- 4 -		5.	0.0	32.69	26.25 ²	- 4 -		5.	1.4	33.34	26.71 ²
- 6 -		0	0.1	32.42	26.05 ²	- 4 -		0	0.2	Below 32.00	
- 6 -		5.	0.2	32.67	26.24	- 6 -		5.	1.0	32.94	26.41
- 6 -		10.	0.3	33.01	26.51 ²	- 6 -		10.	0.7	33.71	27.06 ²
- 8 -	1.2° NE 0.5	0	0.5			- 6 -	-0.6° NNE 0.5	0	-0.5		
- 8 -	79°4' N 20°55' E	5.	0.5	32.91	26.42 ²	- 8 -	79°6' N 27°37' E	5.	1.0	33.04	26.50 ²
- 10 -		0	0.8			- 8 -		0	1.3		
- 10 -		5.	0.8	33.02	26.49	- 10 -		5.	1.4	33.79	27.08
- 12 midn.	79°3' N 25°5' E	0	0.3	32.60	26.19 ²	- 10 -		0	1.5	33.48	26.81 ²
- 12 -		5.	0.6	32.83	26.35	- 12 midn.	79°4' N 27°50' E	0	0.8	32.71	26.24 ²
- 12 -		10.	0.4	33.12	26.59 ²	21, 2 a. m.		0	0.8	33.25	
19, 2 a. m.		0	-0.2	32.43	26.05 ²	- 2 -		5.			
- 2 -		5.	-0.3	32.77	27.34 ²	- 4 -	79°6' N 29°17' E	0	0.0	32.49	26.11 ²
- 4 -	79°3' N 25°5' E	0	0.2			- 4 -		0	-0.5	32.43	26.08 ²
- 4 -		5.	0.0	32.56	26.16 ²	- 6 -		0	0.0		
- 6 -		0	0.1	32.54	26.14 ²	- 8 -	-0.8 NE 1	5.	0.3	32.56	26.15 ¹
- 6 -		5.	0.0	32.50	26.11	- 8 -	79°9' N 30°14' E	0	0.1		
- 6 -		10.	-0.1	32.77	26.33 ²	- 10 -		5.	0.3	32.68	26.25
- 8 -	0.8° SE 0.5	0	0.2			- 10 -		0	0.5	32.62	26.19 ¹
- 8 -	79°3' N 25°5' E	5.	0.1	33.00	26.52 ²	- 12 noon	79°5' N 31°00' E	0			
- 10 -		0	0.3								

¹ Through ice, Sea blue. ² Along ice-edge, Sea blue.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
August 1901		M.	° C.	‰		August 1901		M.	° C.	‰	
21, 12 noon		5*	0.4	32.61	26.18	23, 8 -	79°6' N 29°19' E	5*	0.4	32.64	26.21
- 2 p. m.		0	0.7	32.76	26.29 ¹	- 10 -		0	0.2		2
- 4 -	79°8' N 30°44' E	0	-0.5	32.57	26.19 ¹	- 10 -		5*	0.3	32.66	26.23
- 6 -		0	-0.1	32.86	26.40 ¹	- 12 noon	79°2' N 28°48' E	0	-0.2	32.33?	25.99 ²
- 6 -		5*	0.1	32.93	26.46	- 12 -		5*	-0.1	32.27	25.93
- 6 -		10*	0.1	32.24	26.71	- 12 -		10*	0.1	32.84	26.39
- 8 -	79°10' N 30°15' E	0	-0.2	32.84	26.40 ¹	- 2 p. m.		0	0.0	32.32	25.97 ²
- 10 -		0	0.7			- 2 -		5*	0.0	32.63	26.22
- 10 -		5*	0.8	33.24	26.67	- 2 -		10*	-0.2	32.32	25.98
- 12 midn.	79°15' N 29°35' E	0	0.5	33.24	26.69 ¹	- 4 -	79°4' N 28°25' E	0	-0.4		2
- 12 -		5*	0.6	33.28	26.71	- 4 -		5*	-0.4	32.18	25.87 ²
22, 2 a. m.		0	-0.1	33.18	26.66 ¹	- 6 -		0	0.3	32.46	26.07 ²
- 2 -		5*	0.0	33.25	26.72	- 6 -		5*	0.1	32.60	26.20
- 2 -		10*	-0.6	33.64	27.06	- 6 -		10*	0.0		
- 4 -	79°20' N 28°56' E	0	-0.4		1	- 6 -		15*	0.1	33.73	27.10
- 4 -		5*	-0.4	33.27	26.75 ¹	- 6 -		20*	-0.5	33.25	26.74
- 6 -		0	-0.4	33.21	26.70 ¹	- 6 -		25*	-0.4	33.37	26.83
- 8 -	79°15' N 30°00' E	0	-0.5	32.98	26.52 ¹	- 8 -	79°7' N 28°2' E	0	0.1		2
- 10 -	-0.3 ESE 1	0	-0.3		1	- 8 -	-0.8° SSE 0.5	5*	0.1	32.48	26.10 ²
- 10 -		5*	-0.2	33.20	26.69	- 10 -		0	0.1		
- 12 noon	79°3' N 30°00' E	0	-0.3	33.01	26.53 ¹	- 10 -		5*	0.2	32.53	26.13
- 12 -		5*	-0.2	33.52	26.95 ¹	- 12 midn.	79°9' N 27°39' E	0	0.0	32.39	26.03 ²
- 2 p. m.		0	-0.4	32.86	26.42 ¹	- 12 -		5*	0.1	32.45	26.07
- 4 -		0	0.8			- 12 -		10*	0.2	32.66	26.23 ²
- 4 -	79°1' N 29°10' E	5*	0.8	33.12	26.57	24, 2 a. m.		0	-0.1		
- 6 -		0	0.8	33.22	26.66 ¹	- 2 -		5*	0.1	32.42	26.05
- 6 -		5*	0.9	33.19	26.62 ¹	- 4 -	79°12' N 27°16' E	0	-0.3		2
- 8 -	0.8° ENE 1.0	0	0.6			- 4 -	79°12' N 27°16' E	5*	-0.2	32.41	26.05
- 8 -	79°5' N 29°4' E	5*	0.6	32.96	26.46	- 6 -		0	0.0	32.48	26.10 ²
- 10 -		0	-1.0	32.96	26.53 ¹	- 6 -		5*	0.1	32.53	26.14
- 10 -		5*	-0.9	32.99	26.54	- 6 -		10*	-0.3	32.57	26.18
- 10 -		10*	-1.2	33.39	26.87	- 8 -	79°15' N 26°52' E	0	-0.3		2
- 10 -		15*	-1.3	33.58	27.04 ¹	- 8 -	-1.8° ESE 0.5	5*	-0.4	32.48	26.12 ²
- 10 -		20*	-1.3	33.59	27.04	- 10 -		0	0.1		
- 10 -		25*	-1.3	33.62	27.07	- 10 -		5*	0.1	32.64	26.23
- 12 midn.	79°11' N 30°00' E	0	-0.2	32.91	26.45 ¹	- 12 noon	79°17' N 26°30' E	0	-0.4	32.34	26.00 ²
- 12 -		5*	0.0	32.91	26.44 ¹	- 12 -		5*	-0.4	32.37	26.03
23, 2 a. m.		0	0.3	32.67	26.24 ¹	- 12 -		10*	-0.6	32.92	26.48
- 2 -		5*	0.4			- 12 -		15*	-0.6	33.05	26.58
- 4 -	79°11' N 30°15' E	0	-0.5	32.48	26.12 ¹	- 12 -		20*	-0.3	33.33	26.79
- 6 -		0	0.2	32.57	26.16 ²	- 12 -		25*	-0.8	33.40	26.87 ²
- 8 -	-0.2° ESE 1.0	0	0.3			- 2 p. m.		0	-1.0		
						- 2 -		5*	-1.1	33.26	26.76

¹ In ice. Sea blue. ² Along ice-edge. Sea blue.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
August 1901						August 1901					
24, 4 p. m.	79°17' N 26°28' E	0	-0.8		1	26, 4 a. m.	79°6' N 26°29' E	0	2.0		3
- 4 -		5*	-1.1	32.63	26.26	- 4 -		5*	1.9	33.89	27.11 ³
- 6 -		0	-1.0	32.45	26.11 ¹	- 6 -		0	1.6	33.78	27.05 ³
- 6 -		5*	-1.4	32.84	26.44	- 6 -		5*	1.6	33.78	27.05 ³
- 6 -		10*	-1.5	33.12	26.66	- 6 -		10*	1.6	33.94	27.17 ³
- 8 -	79°17' N 26°25' E	0	-1.6		1	- 8 -	78°55' N 26°28' E	0	1.8	33.78	27.04 ³
- 8 -	-3.0° NE 0.5	5*	-1.6	32.45	26.13 ¹	- 10 -	1.1° NE 1.0	0	1.8	33.78	27.04 ³
- 10 -		0	-1.3			- 12 noon	Cape Arnesen in EbS, 3 miles off	0	1.8	33.60	26.89 ³
- 10 -		5*	-1.3	32.73	26.35	- 2 p. m.		0	0.5		
- 12 -	79°18' N 26°23' E	0	-1.0	32.16	25.88 ¹	- 4 -	Cape Arnesen in NE, 2 miles off	0	0.5	33.94	27.25 ⁴
25, 2 a. m.		0	-0.2	32.66	26.25 ¹	- 6 -		0	1.0		
- 2 -		5*	-0.4	32.67	26.27	- 8 -	-0.2° NNE 1.5	0	0.8	33.72	27.06 ⁴
- 4 -	79°18' N 26°20' E	0	0.0		1	- 8 -		5*	1.1	33.71	27.03 ⁵
- 4 -		5*	0.0	32.62	26.21 ¹	- 8 -	Cape Arnesen in NE, 2 miles off	10*	1.2	33.71	27.02 ⁵
- 6 -		0	0.0	32.60	26.20 ¹	- 10 -		0	1.3	33.26	26.65
- 6 -		5*	0.0	32.88	26.42	- 12 midn.	{ Cape Hammer- fest in NEbN, 3 miles off	0	1.0	33.40	26.79 ²
- 6 -		10*	0.1	32.56	26.16			0	1.2	33.40	26.77 ²
- 8 -	79°19' N 26°17' E	0	-0.9		1	27, 2 a. m.	{ Cape Hammer- fest in NW, 3 miles off	0	1.8	32.92	26.35 ²
- 8 -	-1.5 ENE 1	5*	-0.9	32.36	26.03 ¹	- 4 -		0	1.7	32.83	26.29 ²
- 10 -		0	-1.0	32.27	25.97 ¹	- 6 -	-1.0° NE 1	0	1.5	32.93	26.38 ²
- 10 -		5*	-0.9	32.27	25.96 ¹	- 8 -	{ Cape Weissen- fels in N, 5 miles off	5*	1.4	32.96	26.41 ²
- 10 -		10*	-0.7	33.00	26.55	- 8 -		0	1.5		
- 10 -		15*	-0.8	33.06	26.59	- 10 -		4*	1.5	33.06	26.48
- 10 -		20*	-0.7	33.36	26.84	- 10 -		8*		33.78	
- 10 -		25*	-1.0	33.49	26.95	- 12 noon	{ Cape Weissen- fels in WNW, 4 miles off	0	1.0	33.41	26.80 ²
- 12 noon	79°19' N 26°15' E	0	0.0	32.37	26.01 ¹	- 12 -		5*	1.1	33.46	26.82
- 12 -		5*	-0.1	32.36	26.00	- 12 -		10*	1.2	33.69	27.00 ²
- 12 -		10*	-0.5	32.88	26.44	- 2 p. m.		0	1.0		
- 12 -		15*	-0.4	33.16	26.67	- 2 -		5*	1.0	33.86	27.14 ²
- 12 -		20*	-0.6	33.37	26.84	- 4 -	Cape Altman in N, 8 miles off	0	1.3		
- 12 -		25*	-0.8	33.55	26.99 ¹	- 4 -		5*	0.8	33.80	27.11 ²
- 2 p. m.		0	-0.7			- 5 -		0	1.4	33.70	27.00 ²
- 2 -	79°17' N 26°20' E	5*	-0.7	32.25	25.94 ¹	- 5 -		5*	1.2	33.80	27.09
- 4 -		0	-1.2			- 5 -		10*	1.0	33.87	27.16
- 4 -		5*	-1.2	32.42	26.09 ¹	- 5 -		15*	1.0	33.85	27.14
- 6 -		0	-0.8	32.24	26.94 ¹	- 5 -		20*	0.8	33.90	27.40
- 6 -		5*	-1.1	32.27	25.97	- 5 -		25*	0.6	33.96	27.26 ⁶
- 6 -		10*	-1.1	32.93	26.50 ¹	- 8 8 -	1.2° N 0.5	0	1.1		
- 8 -	79°15' N 26°25' E	0	-1.1		1	- 8 -	Cape Altman in N, 8 miles off	5*	1.0	33.71	27.03 ²
- 8 -	-1.2° NE 1	5*	-1.1	32.28	25.98 ¹	- 10 -		0	0.9		
- 10 -		0	-0.7			- 10 -		5*	0.9	33.41	27.80
- 10 -		5*	-0.5	32.28	25.96 ²	- 12 midn.	{ Cape Altman in NW, 8 miles off	0	0.6	33.61	26.98 ⁷
- 12 midn.	79°16' N 26°36' E	0	-0.7	32.28	25.97 ²						
- 12 -		5*	-0.4	32.32	25.99						
- 12 -		10*	-0.3	32.79	26.36						
- 12 -		25*	-0.7	33.18	26.69						
- 12 -		20*	-0.7	33.31	26.80						
- 12 -		25*	-0.7	33.41	26.88 ²						
26, 2 a. m.		0	-0.5	32.29	25.96 ²						

¹ Along ice-edge. Sea blue. ² In open sea, colour blue. ³ In open sea, colour somewhat darker blue.
⁴ At anchor off Cape Arnesen. ⁵ Left Cape Arnesen at 8.15 p. m. ⁶ A red medusa was seen. ⁷ Many small red medusæ were seen.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
August 1891		M.	° C.	‰		August 1901		M.	° C.	‰	
27, 12 midn.		5*	0.7	33.72	27.06 ¹	29, 12 midn.	{ 77°38' N 32°00' E	0	1.9	33.24	26.60 ⁶
28, 2 a. m.		0	0.7			30, 1 a. m.	{ 77°21' N 31°20' E	0	1.7	33.21	26.58 ⁶
- 2 -		5*	0.6	33.67	27.02	- 2 -		0	1.9	33.28	26.62 ⁶
- 4 -	{ King Charles Land in NW, 8 miles off	0	1.3		¹	- 3 -		0	1.9	33.23	26.59 ⁶
- 4 -		5*	1.0	33.03	26.48	- 4 -		0	2.0	33.33	26.66 ⁶
- 6 -		0	1.3	32.95	26.41 ¹	- 5 -		0	2.1	33.54	26.82 ⁶
- 8 -	{ 78°32' N 32°12' E	0	1.3	32.89	26.36 ¹	- 6 -		0	2.1	33.58	26.86 ⁶
- 10 -	-2.2 NNE 1	0	1.3	33.13	26.55 ¹	- 7 -		0	2.1	33.47	26.76 ⁶
- 10 -		5*	1.1	33.40	26.78	- 8 -	{ 77°4' N 30°40' E	0	2.1	33.60	26.77 ⁶
- 12 noon	{ 78°30' N 33°30' E	0	1.4	33.15	26.56 ¹	- 9 -		0	2.1	33.62	26.89 ⁶
- 12 -		5*	1.5	33.20	26.59	- 10 -	13° NE b N 1.5	0	2.1	33.51	26.80 ⁶
- 12 -		10*	1.4	33.11	26.52 ¹	- 11 -		0	2.1	33.49	26.78 ⁶
- 2 p. m.		0	1.4	33.22	26.62 ²	- 12 noon	{ 76°47' N 30°00' E	0	2.2	33.49	26.77 ⁶
- 2 -		5*	1.4	33.24	26.63 ²	- 1 p. m.		0	2.3	33.53	26.79 ⁶
- 4 -	{ 78°32' N 33°50' E	0	0.9	33.24	26.66 ¹	- 2 -		0	2.4	33.58	26.83 ⁶
- 6 -		0	0.8	33.04	26.51 ³	- 3 -		0	2.4	33.58	26.83 ⁶
- 8 -	{ 78°33' N 34°10' E	0	0.2	32.95	26.47 ³	- 4 -	{ 76°29' N 29°33' E	0	2.6	33.68	26.89 ⁶
- 10 -	-2.5° N 1	0	0.4		³	- 5 -		0	2.6	33.64	26.86 ⁶
- 10 -		5*				- 6 -		0	2.6	32.72	26.93 ⁶
- 12 midn.	{ 78°35' N 34°29' E	0	0.3	33.04 32.94	26.45 ³	- 7 -		0	2.4	33.78	26.99 ⁶
- 12 -		5*	0.4	32.95	26.46	- 8 -	{ 76°11' N 29°6' E	0	2.6	33.78	26.98 ⁶
- 12 -		10*	0.3	33.08	26.57	- 9 -		0	2.7	33.78	26.97 ⁶
29, 2 a. m.		0	0.5	33.07	26.55 ⁴	- 10 -	0.7° NE 1	0	2.7	33.78	26.97 ⁷
- 2 -		5*	0.7	33.09	26.55	- 11 -		0	2.7	33.74	26.93 ⁷
- 2 -		10*	0.7	33.22	26.66	- 12 midn.	{ 75°53' N 28°36' E	0	2.7	33.75	26.94 ⁷
- 2 -		15*	0.7	33.27	26.69	31, 1 a. m.		0	2.4	33.90	27.08 ⁷
- 2 -		20*	0.3	33.34	26.78	- 2 -		0	2.6	33.82	27.00 ⁷
- 2 -		25*	-0.1	33.49 ²	26.91	- 3 -		0	2.5	33.86	27.03 ⁷
- 4 -	{ 78°39' N 34°10' E	0	-0.3	32.71	26.28 ⁴	- 4 -	{ 75°35' N 28°9' E	0	2.5	33.78	26.98 ⁷
- 6 -		0	-0.2	32.79	26.36 ⁴	- 5 -		0	2.6	33.72	26.93 ⁷
8 8 -	{ 78°44' N 34°00' E	0	0.2	32.95	26.47 ⁴	- 6 -		0	3.0	33.69	26.87 ⁷
- 10 -	-1.3 NNW 1.5	0	-0.5	32.67	26.27 ⁴	- 7 -		0	3.0	33.69	26.87 ⁷
- 12 noon	{ 78°29' N 34°25' E	0	1.2	33.03	26.48 ⁵	- 8 -	{ 75°18' N 27°42' E	0	3.0	33.66	26.84 ⁷
- 12 -		3*	1.2	33.02	26.47 ⁵	- 9 -		0	3.1	33.49	26.67 ⁷
- 2 p. m.		0	1.0	33.15	26.58 ⁵	- 10 -	1.9° NNE 1	0	3.1	33.50	26.67 ⁷
- 3 -		0	1.3	33.06	26.49 ⁵	- 11 -		0	3.2	33.58	26.76 ⁷
- 4 -	{ 78°12' N 33°20' N	0	1.3	33.17	26.58 ⁵	- 12 noon	{ 75°00' N 26°20' E	5	3.3	33.59	26.77 ⁷
- 5 -		0	1.3	33.08	26.51 ⁶	- 1 p. m.		0	3.2	33.65	26.81 ⁷
- 6 -		0	1.5	32.98	26.41 ⁶	- 2 -		0	3.3	33.64	26.79 ⁷
- 7 -		0	1.6	33.09	26.50 ⁶	- 3 -		0	3.5	33.72	26.84 ⁷
- 8 -	{ 77°55' N 32°40' E	0	1.2	33.05	26.49 ⁶	- 4 -	{ 74°47' N 26°3' E	0	3.6	33.62	26.76 ⁷
- 9 -		0	1.6	33.05	26.47 ⁶	- 5 -		0	3.6	33.53	26.68 ⁷
- 10 -	-0.3° N 2	0	1.7	33.11	26.50 ⁶	- 6 -		0	3.5	33.54	26.70 ⁷
- 11 -		0	2.0	33.33	26.66 ⁶	- 7 -		0	3.4	33.51	26.69 ⁷
						- 8 -	{ 74°34' N 25°26' E	0	3.4	33.51	26.69 ⁷

¹ In open sea, colour blue. ² A red medusa, of 15 cm. diameter, was seen. ³ Through ice, sea blue. ⁴ In ice, sea grayish-blue. ⁵ Sea somewhat darker blue. ⁶ Sea dark blue. ⁷ Sea blue. The sea becomes darker gradually as the temperature rises.

Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t	Date and Hour	Locality Air Temperature Wind	Depth in Metres	Tempera- ture	Salinity ‰	σ_t
August 1901		M.	° C.	‰		Sept. 1901		M.	° C.	‰	
9 p. m.		0	3.5	33.58	26.73 ¹	2. 5 a. m.		0	8.0	34.83	27.17 ¹
10 -	1.0° NNE 0.5	0	3.6	33.50	26.66 ¹	- 6 -		0	7.9	34.84	27.19 ¹
11 -		0	3.7	33.51	26.66 ¹	- 7 -		0	7.9	34.86	27.20 ¹
12 midn.	74°21' N 25°29' E	0	3.7	33.50	26.65 ¹	- 8 -	71°40' N 24°48' E	0	7.9	34.87	27.21 ¹
						- 9 -		0	8.1	34.88	27.18 ¹
Sept. 1901						- 10 -	5.3° ENE 1	0	8.0	34.88	27.20 ¹
1 a. m.		0	3.7	33.53	26.67 ¹	- 11 -		0	8.0	34.88	27.20 ¹
2 -		0	3.9	33.58	26.70 ¹	- 12 noon	71°10' N 24°50' E	0	8.1	34.88	27.18 ¹
3 -		0	3.9	33.61	26.72 ¹	1 p. m.		0	8.1	34.88	27.18 ¹
4 -	74°00' N 25 12' E	0	4.0	33.65	26.74 ¹	- 2 -		0	8.2	34.89	27.18 ¹
5 -		0	4.0	33.65	26.74 ¹	- 3 -		0	8.2	34.89	27.18 ¹
6 -		0	5.5	34.32	27.10 ¹	4 -	71°23' N 23°12' E	0	8.5	34.86	27.11 ¹
7 -		0	5.5	34.35	27.13 ¹	- 5 -		0	8.8	34.80	27.02 ¹
8 -	73°50' N 24°56' E	0	5.7	34.36	27.11 ¹	- 6 -		0	8.5	34.91	27.15 ¹
9 -		0	5.8	34.24	27.06 ¹	- 8 -	North point Sero in SbE, 4 miles off	0	8.9	34.69	26.93 ¹
10 -	1.8° NE 1.5	0	5.7	34.46	27.18 ¹	- 10 -	4.8 NNE 0.5	0	9.0	34.64	26.94 ¹
11 -		0	5.5	34.46	27.20 ¹	- 12 midn.	SW point Sero in SW 16 miles off	0	9.1	34.58	26.80 ¹
12 noon	73°39' N 24°40' E	0	5.8	34.41	27.13 ¹	3. 2 a. m.		0	9.2	34.58	26.78 ²
1 p. m.		0	5.8	34.39	27.12 ¹	- 4 -	SW point Sero in SE, 4 miles off	0	9.5	34.49	26.66 ²
2 -		0	5.9	34.46	27.17 ¹	- 6 -		0	10.0	34.25	26.38 ²
3 -		0	6.0	34.61	27.26 ¹	- 8 -	Loppen in SSE, 8 miles off	0	9.8	33.89	26.14 ²
4 -	73°14' N 24°38' E	0	6.2	34.61	27.23 ¹	- 10 -	7° WNW 1	0	9.3	33.03	25.56 ²
5 -		0	6.2	34.55	27.19 ¹	- 12 noon		0	9.1		
6 -		0	7.2	34.48	27.00 ¹	- 2 p. m.		0	9.3		
7 -		0	6.8	34.86	27.37 ¹	- 4 -		0	9.2		
8 -	72°49' N 24°37' E	0	7.2	34.93	27.35 ¹	- 6 -		0	9.2		
9 -		0	7.2	34.89	27.33 ¹	- 8 -	7.0° W 1	0	9.1		
10 -	2.8° NE 1.5	0	7.8	34.89	27.24 ¹	- 10 -		0	9.1		
11 -		0	7.8	34.91	27.25 ¹	- 12 midn.		0	9.0		
12 midn.	72°24' N 24°43' E	0	7.7	34.92	27.28 ¹	4. 2 a. m.		0	9.0		
1 a. m.		0	7.9	34.85	27.19 ¹	- 4 -		0	8.9		
2 -		0	7.8	34.89	27.24 ¹	- 6 -		0	8.9		
3 -		0	8.0	34.83	27.17 ¹	- 8 -	6.5° SW 1	0	8.2		
4 -	71°59' N 24°45' E	0	8.0	34.80	27.14 ¹	- 10 -		0	8.5		
						- 12 noon		0	8.4		

¹ Sea blue. The sea becomes darker gradually as the temperature rises. ² Sea dark green.

Table II.

Vertical Series of Temperatures, Salinities, and Densities taken at Amundsen's Stations in Arctic Seas, April—August 1901.

Explanation of Table II.

-
- 1st Column.* Number of Station, where the temperatures and water-samples were taken.
- 2nd Column.* Date and Locality of Station. *N* indicates North Latitude. *E* or *W* Longitude East or West of Greenwich.
- 3rd Column.* Hour at which the observations were taken.
- 4th Column.* Depth in Metres. A line under the figures indicates bottom.
- 5th Column.* Designation of the Thermometer used. *R 9* and *R 10* = Nansen Deep Sea Thermometers (from C. Richter) Nos. 109 and 110 (they were used with the Pettersson-Nansen Insulated Water-Bottle, see pp. 5 and 3). *R 13* = Richter Reversing Thermometer No. 113 (see p. 3). *Z 12* and *Z 20* = Negretti and Zambra Reversing Thermometers Nos. 72012 and 72620 (see p. 4). The water-samples were taken with the small water-bottle of the writer's construction (mentioned p. 1) when the Reversing Thermometers *R 13*, *Z 12* and *Z 20* were used. *638* = Thermometer No. 638 (see p. 6) used for taking the temperatures with Amundsen's Water-Bottle (see p. 7).
- 6th Column.* Correct Temperature of the Water Strata *in situ* (referred to the Hydrogen Thermometer). The temperature-readings have been corrected for the instrumental errors; and those of the reversing thermometers also for the errors caused by the higher temperature of the broken off mercury, at the moment the reading was taken.
- 7th Column.* Permillage of Chlorine (Halogen) in Water-Samples, as determined by Titrations (Mohr), made by Mr. I. Leivestad.
- 8th Column.* Salinity (‰) computed from the Chlorine, by Knudsen's Tables.
- 9th Column.* Density (σ_t) of Sea Water *in situ*, referred to a pressure of one atmosphere, and computed from Chlorine and Temperature by Knudsen's Tables.
- $$\sigma_t = \left(s \frac{t}{4} - 1 \right) \cdot 1000.$$
-

Table II. Deep Sea Observations.

Station	Date and Locality	Hour	Depth in Metres	Designation of Thermometer	Corr Temperature <i>in situ</i>	Chlorine Cl ‰	Salinity S ‰	Density <i>in situ</i>
	1901		M.		° C.	‰	‰	σ_t
1	April 25 70°55' N 41° 0' E	4.10 p. m.	220	R 10	0.63	19.135	34.57	27.74
2	April 26 70°25' N 42°24' E	Noon	0	638	-0.3	19.21	34.70	27.91
		11.35 a. m.	10	R 10	-0.53	.20	.69	.90
		11.25 -	20	-	-0.53	.18	.65	.87
		11.20 -	40	-	-0.53	.165	.62	.85
		11.10 -	60	-	-0.84			
		11.0 -	80	-	-0.95	.17	.63	.87
		10.20 -	100	-	-0.88	.235	.75	.97
			104					
3	April 28 71°33' N 45°30' E	11.30 a. m.	0	638	-0.2	19.23	34.74	27.93
		11.15 -	5	R 9	-0.23	.235	.75	.94
		11.04 -	25	-	-0.23	.235	.75	.94
		10.55 -	35	-	0.15	.27	.81	.97
		10.48 -	45	-	0.39	.29	.85	.98
		10.40 -	70	-	0.45	.315	.89	28.01
		10.35 -	95	-	0.48	.305	.88	.00
		10.25 -	120	-	0.48	.32	.90	.02
		10.15 -	145	-	0.29	.32	.90	.03
		10.05 -	170	-	0.21	.315	.89	.03
		9.55 -	195	-	-0.12	.33	.92	.07
		9.30 -	215	-	-0.90	.32	.90	.09
			254					
	71°31' N 45°30' E							
4	April 30 70°10' N 47°34' E	0.35 p. m.	0	638	-1.8	19.095 ¹	34.50?	27.79?
		0.26 -	10	R 10	-1.82	.03	.35	.70
		0.18 -	20	-	-1.80	.045	.41	.72
		0.12 -	30	-	-1.79	.045	.41	.72
		0.05 -	40	-	-1.31	.145	.59	.85
		Noon	50	-	-1.01	.175	.64	.88
		11.53 a. m.	60	-	-0.40	.245	.77	.96
		11.45 -	70	-	-0.37	.27	.81	28.00
		11.37 -	80	-	-0.21	.28	.83	.00
		11.30 -	90	-	-0.43	.28	.83	.01
		11.24 -	100	-	-0.68	.28	.83	.02
		11.17 -	115	-	-0.75	.285	.84	.03
		11.05 -	125	-	-0.75	.285	.84	.03
			132					

¹ This value of Chlorine seems somewhat high. The water-sample was taken with Amundsen's Water-Bottle, and a little ice may possibly have frozen out on the glass-walls.

Station	Date and Locality	Hour	Depth in Metres	Designation of Thermometer	Corr. Temperature <i>in situ</i>	Chlorine Cl. ‰	Salinity S ‰	Density <i>in situ</i>
	1901		M.		° C	‰	‰	σ_t
5	May 2 71° 4' N 45° 38' E	6:10 p. m.	0	638	-0.35	19.23	35.74	27.94
		6:02 -	5	R 9	-0.30	.24	.76	.95
		5:57 -	10	-	-0.29	.235	.75	.94
		5:51 -	30	-	-0.32	.24	.76	.95
		5:45 -	50	-	-0.27	.245	.77	.95
		5:23 -	80	-	-0.25	.245	.77	.95
		4:57 -	90	-	-0.15	.265	.80	.98
		4:51 -	100	-	0.05	.255	.79	.95
		4:45 -	110	-	0.16	.275	.82	.97
		4:37 -	120	-	0.16	.27	.81	.97
		4:30 -	130	-	0.20	.285	.84	.98
		4:20 -	146	-	0.21	.275	.82	.97
		4:10 -	155	-	0.22	.27	.81	.96
			166	-				
6 ¹	May 9 69° 32' N 45° 37' E	6:30 p. m.	0	638	-1.5	19.04	34.40	27.70
		6:24 -	10	Z 12	-1.68	.025	.37	.69
		6:07 -	20	Z 20	-1.83	.03	.38	.70
		5:55 -	30	Z 12	-1.83	.03	.38	.70
		5:38 -	40	Z 20	-1.83	.03	.38	.70
		5:25 -	50	Z 12	-1.88 ²	.04	.40	.71
		5:10 -	60	Z 20	-1.88 ²	.035	.39	.71
			70					
7	May 13 69° 40' N 46° 30' E	0:20 a. m.	0	638	-1.2	18.965	34.26	27.58
		0:30 -	25	Z 12	[-0.48] ³	19.03	.38	[.65]
	May 12	11:53 p. m.	40	Z 20	-1.69	.035	.39	.70
		11:40 -	50	Z 12	[-0.79] ³	.045	.41	[.60]
		11:28 -	60	Z 20	-1.14	.135	.57	.83
		10:57 -	70	Z 12	[-0.28] ³	.205	.70	[.89]
		10:45 -	80	Z 20	-1.24	.245	.77	.99
8	May 16 69° 40' N 46° 20' E	1:45 p. m.	0	638	-1.0	19.04	34.40	27.69
		1:40 -	1	-	-0.9	.035	.39	.68
		1:35 -	3	-	-0.9	.04	.40	.68
		0:52 -	5	R 13	-0.94	.025	.37	.66
		0:23 -	10	-	-1.41	.025	.37	.68
		0:10 -	20	-	-1.68	.07	.45	.75
		11:55 a. m.	30	-	-1.78	.08	.47	.77
		11:42 -	40	-	-1.77	.09	.49	.78
		11:10 -	50	Z 20	-1.81	.08	.47	.77
		0:38 p. m.	-	R 13	-1.22			
		10:43 a. m.	60	Z 20	-1.51	.08	.47	.76
		10:18 -	70	-	-1.21	.145	.59	.85
		0:38 p. m.	-	R 13	-1.32			
			80					
9	May 20 70° 0' N 42° 45' E	0:50 p. m.	0	638	-1.2	19.095	34.50	27.77
		0:45 -	5	-	-1.2	.085	.48	.76
		0:40 -	10	-	-1.2	.095	.50	.77

¹ Another series of water samples (from 1-40 metres) were taken at this Station, between 6:40 and 7:30 p. m. The determinations of Specific Gravity and Chlorine are given on p. 10. ² The readings have probably been slightly too low, which may easily happen with these thermometers, only divided into whole degrees. The freezing-point of this water, was about -1.876° C. ³ The Negretti and Zambra reversing thermometer no. 72012 (Z 12) has obviously not worked properly on this day, and has given erroneous readings.

Station	Date and Locality	Hour	Depth in Metres	Designation of Thermometer	Corr. Temperature <i>in situ</i>	Chlorine Cl ‰	Salinity S ‰	Density <i>in situ</i>
10	1901 May 20		M.		° C.	‰	‰	σ_t
			50			19.12	34.54	
		0.23 p. m.	60	R 13	-1.79	.125	.55	27.83
		0.08 -	70	-	-1.73	.13	.56	.84
		11.40 a. m.	80	-	-1.56	.14	.58	.85
		11.25 -	90	-	-1.45	.135	.57	.84
		10.37 -	100	-	-1.44	.265	.80	28.03
		10.20 -	110	-	-1.49	.27	.81	.04
			123	-				
	May 22 71°12' N 44°10' E	11.25 p. m.	0	638	-1.6	19.10	34.51	27.79
		11.20 -	5	-	-1.6	.095	.50	.78
		11.13 -	10	Z 20	-1.76	.095	.50	.79
		11.0 -	25	Z 12	-1.69	.10	.51	.80
		10.47 -	50	Z 20	-1.71	.115	.53	.92
		10.33 -	75	Z 12	-1.69	.23	.74	.98
		10.20 -	100	Z 20	-1.03	.275	.82	28.03
		10.05 -	125	Z 12	-0.94	.29	.85	.05
		9.50 -	150	Z 20	-0.89	.305	.88	.07
			164					
11	May 31 73°07' N 36°43' E	10.43 a. m.	275	Z 20	-1.40	19.345	34.95	28.14
		10.17 -	300	-	-1.40	.34	.94	.14
			337					
12	June 5 73°50' N 87°50' E	5.0 a. m.	0	638	-1.1	19.165	34.62	27.87
		4.55 -	5	-	-1.0	.175	.64	.88
		4.50 -	10	-	-1.0	.18	.65	.89
		4.45 -	15	-	-0.8	.17	.63	.87
		4.31 -	50	R 13	-1.34	.20	.69	.93
		4.11 -	75	-	-0.34	.27	.81	28.00
		4.20 -	85	-	0.29	.31	.88	.01
		3.50 -	100	-	0.29	.31	.88	.01
		4.01 -	125	-	-0.06	.27	.81	27.98
		3.40 -	150	-	-1.22	.32	.90	28.10
		3.29 -	175	-	-1.23	.31	.88	.09
		2.47 -	200	-	-1.62	.295	.86	.08
		2.19 -	225	-	-1.67	.305	.88	.09
		2.02 -	250	-	-1.67	.30	.87	.09
		1.42 -	275	-	-1.70			
			-	Z 20	-1.71			
			290					
13	June 19 74°18' N 3°25' E	10.30 p. m.	0	638	0.0	19.01	34.34	27.60
		10.15 -	25	Z 20	-1.15	.03	.38	.68
		9.59 -	50	-	-1.37	.27	.81	28.03
		9.42 -	100	-	-1.05	.27	.81	.02
		9.21 -	150	R 13	-0.99	.305	.88	.07
		8.59 -	200	Z 20	-1.00	.315	.89	.08
		8.40 -	225	-	-1.05	.335	.93	.12
		8.18 -	250	-	-1.23	.315	.89	.10
		7.12 -	275	-	-1.15			
			-	R 13	-1.08	.325	.91	.10
		6.50 -	300	Z 20	-1.11	.325	.91	.11
		6.32 -	350	R 13	-1.04			
		6.07 -	400	Z 20	-1.15			
			-	R 13	-1.04	.31	.88	.08
		5.38 -	450	Z 20	-1.11	.325	.91	.10
		5.12 -	500	Z 20	-1.15	.335	.93	.12
			-			.335	.93	
		4.30 -	700	Z 20	-1.15	.33	.92	.11
		2.58 -	1000	-	-1.34	.325	.91	.11

Station	Date and Locality	Hour	Depth in Metres	Designation of Thermometer	Corr. Temperature <i>in situ</i>	Chlorine Cl ‰	Salinity S ‰	Density <i>in situ</i>
	1901		M.		° C.	‰ ₁₀₀	‰ ₁₀₀	σ_t
	June 19		1000	R 13	-1.17	19.325	34.91	28.11
		1.10 p. m.	1200	Z 20	-1.30	.305	.875	.08
			-	-	-	.31	.885	.09
		0.15 -	1500	-	-1.40	.33	.92	.12
14	June 20	4.05 p. m.	0	638	0.2	19.035	34.39	27.62
	{ 74°5' N	3.51 -	20	Z 20	-0.21	.18	.65	.85
	{ 3°27' W	3.36 -	40	-	-1.05	.25	.78	28.00
		3.20 -	60	-	-1.25	.28	.83	.05
		3.04 -	80	-	-1.25	.30	.87	.07
		2.46 -	100	-	-1.23	.30	.87	.07
15	June 25	0.20 p. m.	0	R 9	0.51	18.88	34.11	27.38
	{ 74°10' N	0.30 -	20	R 13	0.26	19.08	.47	.68
	{ 1°14' W	0.43 -	60	-	0.35	.335	.93	28.05
		1.17 -	70	-	-0.08	.32	.90	.05
		1.06 -	80	-	-0.31	-	-	-
		0.54 -	100	-	-1.04	.315	.89	.09
		1.28 -	150	-	-0.68	.33	.92	.09
		1.54 -	200	-	-1.03	.305	.88	.07
		2.06 -	300	-	-1.16	.325	.91	.11
		2.30 -	400	-	-1.07	.33	.92	.11
		2.50 -	500	-	-1.08	.32	.90	.10
		5.17 -	1000	-	-1.34	.335	.93	.13
		6.03 -	1500	-	-1.37	.31	.88	.09
		7.24 -	2000	-	-1.30	.315	.89	.10
16	June 27	8.55 a. m.	0	R 9	0.85	19.01	34.34	27.55
	{ 74°48' N	9.0 -	20	R 13	0.26	.025	.37	.60
	{ 4°00' W	10.02 -	-	-	0.26	-	-	-
		9.52 -	25	-	-0.38	.05	.42	.67
		9.43 -	30	-	-0.33	.155	.61	.83
		9.32 -	40	-	-0.61	.26	.79	.99
		9.22 -	50	-	-0.92	.255	.79	28.00
		9.10 -	60	-	-1.05	.285	.84	.04
		10.13 -	100	-	-1.10	.31	.88	.08
		10.23 -	150	-	-1.11	.31	.88	.08
		10.36 -	200	-	-1.01	.32	.90	.09
		10.50 -	300	-	-1.07	.32	.90	.10
		11.07 -	400	-	-1.07	.315	.89	.09
		11.22 -	500	-	-1.21	.32	.90	.10
		11.42 -	600	-	-1.24	.32	.90	.10
		12.10 p. m.	700	-	-1.25	-	-	-
		12.33 -	800	-	-1.25	.325	.91	.11
		3.33 -	1000	-	-1.29	.325	.91	.11
			-	Z 20	-1.40	.315	.89	.10
		4.10 -	1200	R 13	-1.30	.315	.89	.10
			-	Z 20	-1.40	-	-	-
		4.50 -	1500	R 13	-1.33	.33	.92	.12
			-	Z 20	-1.42	-	-	-
		6.0 -	1700	R 13	-1.30	.315	.89	.10
			-	Z 20	-1.39	-	-	-
		6.56 -	2000	R 13	-1.30	.32	.90	.10
			-	Z 20	-1.39	.315	.89	.10
17	June 29	5.40 p. m.	0	638	0.7	18.71	33.80	27.12
	{ 74°42' N	6.13 -	20	R 13	0.19	.825	34.01	.32
	{ 5°51' W	6.04 -	25	-	-0.14	.915	.17	.47
		5.50 -	30	Z 20	-0.87	19.045	.41	.68
		8.55 -	40	R 13	-0.96	.175	.64	.88
		9.11 -	50	-	-0.76	.275	.82	28.02

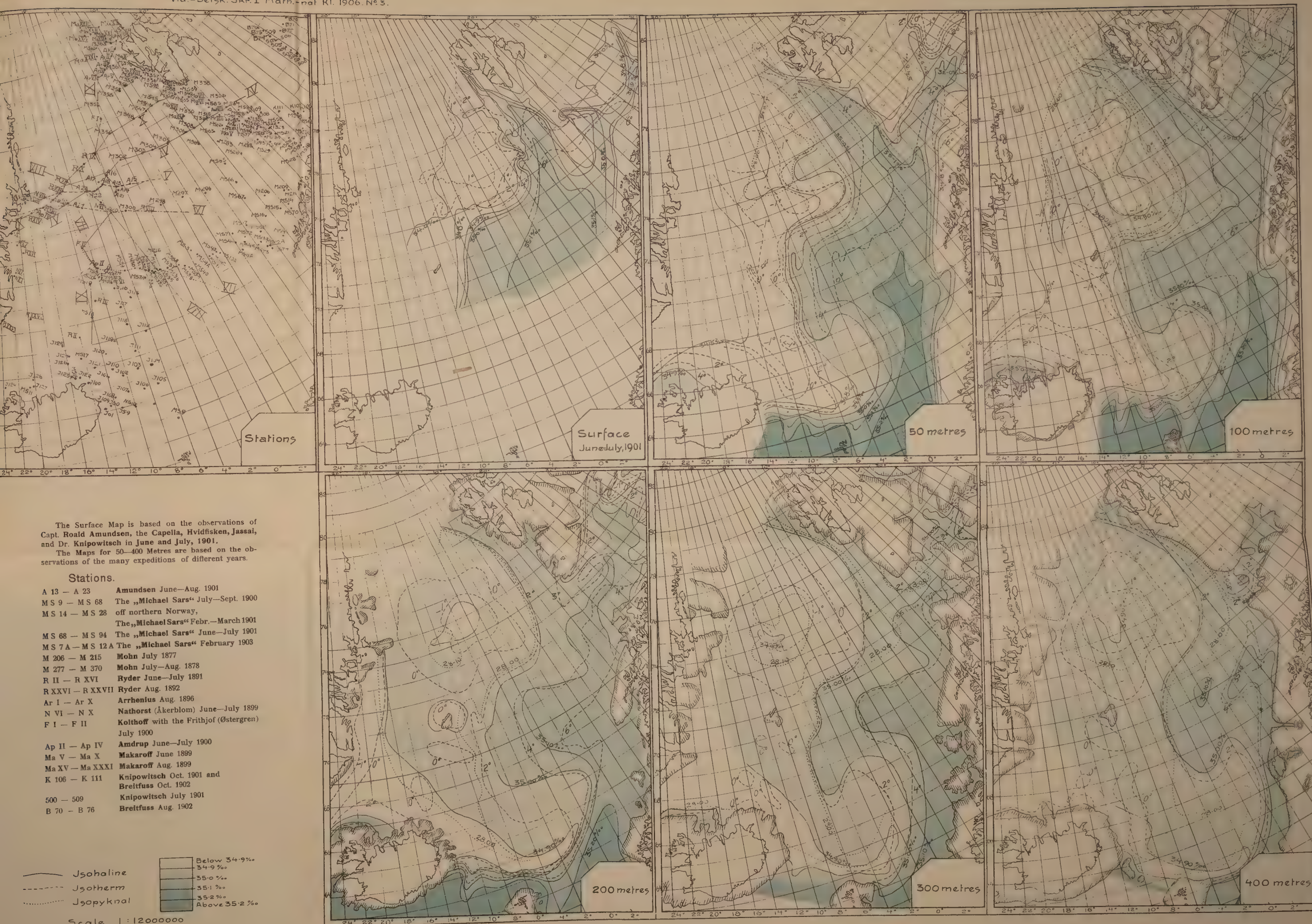
Station	Date and Locality	Hour	Depth in Metres	Designation of Thermometer	Corr. Temperature in situ	Chlorine Cl ‰	Salinity S ‰	Density in situ
	1901		M.		° C.	‰ ₀₀	‰ ₀₀	σ_t
17	June 29	6:23 p. m.	60	R 13	0.05	19.31	34.88	28.03
		8:42 -	70	-	0.05	.31	.88	.03
		9:22 -	60	-	-0.09			
		9:36 -	-	-	-0.20			
		9:50 -	-	Z 20	-0.42	.315	.89	.06
		10:20 -	-	R 13	-0.57			
		-	-	Z 20	-0.71			
		10:35 -	-	R 13	-0.63			
		-	-	Z 20	-0.74			
		10:51 -	-	R 13	-0.51			
		-	-	Z 20	-0.64			
		11:05 -	-	R 13	-0.67			
		-	-	Z 20	-0.79			
		11:15 -	-	R 13	-0.67			
		-	-	Z 20	-0.79			
		11:31 -	-	R 13	-0.67	.29	.85	.04
		-	-	Z 20	-0.79			
18	July 1 74°34' N 5°25' W	1:40 a. m.	0	638	1.0	18.65	33.69	27.01
		Midn.	60	R 13	-0.67	19.27	34.81	28.01
		-	-	Z 20	-0.79			
		0:13 a. m.	100	R 13	-0.67	.325	.91	.09
		0:25 -	150	-	-0.68			
		0:39 -	200	-	-0.80	.335	.93	.11
		0:55 -	300	-	-0.92	.325	.91	.10
		1:13 -	400	-	-1.03	.325	.91	.10
		1:32 -	500	-	-1.10	.33	.92	.11
		-	-	-	-			
19	July 3 73°52' N 9°13' W	2:45 a. m.	0	638	0.7	18.505	33.43	26.83
		3:12 -	10	R 13	0.54	.515	.45	.85
		3:21 -	15	-	-0.42	.57	.55	.98
		2:51 -	20	-	-0.86	.775	.92	27.30
		-	-	Z 20	-0.94			
		3:02 -	60	R 13	-0.75	19.27	34.81	28.02
		3:32 -	100	-	-0.52	.32	.90	.07
		-	-	Z 20	-0.62	.32	.90	.08
		3:45 -	150	R 13	-0.68	.32	.90	.08
		3:59 -	200	-	-0.75	.32	.90	.08
		-	-	Z 20	-0.84			
		4:16 -	300	R 13	-0.92	.325	.91	.10
		4:41 -	400	-	-0.85	.335	.93	.11
		-	-	Z 20	-0.95			
		5:06 -	500	R 13	-1.01	.33	.92	.11
		5:20 -	700	-	-1.12	.33	.92	.11
		-	-	Z 20	-1.25			
20	July 4 73°18' N 5°28' W	Midn.	0	638	-0.1	18.16	32.81	26.36
		9:35 p. m.	0	-	0.8	.295	33.05	.52
		9:33 -	20	R 13	-0.15	.845	34.05	27.36
		9:21 -	60	-	-0.83	19.26	.79	.99
		-	-	Z 20	-0.89			
		9:01 -	100	R 13	-0.79	.325	.91	28.09
		8:47 -	150	-	-0.84	.345?	.95?	.13?
		-	-	Z 20	-0.94			
		7:35 -	200	R 13	-0.96	.33	.92	.11
		-	-	Z 20	-1.05			
		7:17 -	250	R 13	-0.99	[.40]	[35.05]	
		7:01 -	300	-	-0.96	.325	34.91	.10
		-	-	Z 20	-1.10			
		6:41 -	400	R 13	-0.99	.33	.92	.11
		6:20 -	500	-	-1.04	.33	.92	.11

Station	Date and Locality	Hour	Depth in Metres	Designation of Thermometer	Corr. Temperature <i>in situ</i>	Chlorine Cl ‰	Salinity S ‰	Density <i>in situ</i>
	1901		M.		° C.	‰	‰	σ_t
20	July 4		500	Z 20	-1.14			
		9.49 p. m.	700	R 13	-1.16	19.335	34.93	28.12
				Z 20	-1.21			
		10.19 -	1000	R 13	-1.16	.33	.92	.11
		10.51 -	1500	-	-1.20	.325	.91	.11
				Z 20	-1.29			
		11.40 -	2000	R 13	-1.26	.325	.91	.11
				Z 20	-1.36			
21	July 8 74°4' N 3°48' W	9.40 a. m.	0	638	2.3	19.065	34.44	26.52
		9.42 -	20	Z 20	0.52	.105	.52	.71
		10.08 -	25	-	-0.18	.17	.63	.84
		9.56 -	60	Z 12	-0.88	.30	.87	28.06
		10.21 -	100	-	-0.83	.325	.91	.10
		10.32 -	150	Z 20	-1.03	.325	.91	.10
		10.45 -	200	Z 12	-1.09	.325	.91	.10
		10.38 -	300	Z 20	-1.19	.315	.89	.09
22 ¹	July 10 74°26' N 6°40' W	10.0 p. m.	0	638	0.4	18.115	32.73	26.27
			5	-	0.6	.145	.78	.31
			10	-	0.4?	.165?	.82?	.35?
			15	-	0.2?	.60?	33.60?	.99?
			20	-	0.0?	.70?	.78?	27.15?
			25	-	-0.1?	.705?	.79?	.16?
		11.08 -	60	Z 12	[-0.63] ²	19.30	34.87	28.05?
		11.21 -	100	Z 20	-0.90	.32	.90	.09
		11.35 -	150	Z 12	[-0.14] ²	.32	.90	
		0.25 a. m.	-	Z 20	-0.93			.09
	July 11	11.47 p. m.	200	-	-0.89	.32	.90	.09
	July 10	0.10 a. m.	300	Z 12	[-0.60] ²	.31	.88	
	July 11	0.48 -	400	Z 20	-1.15	.33	.92	.11
		1.11 -	500	-	-1.15	.325	.91	.11
		1.13 -	1000	-	-1.25	.325	.91	.11
23	July 11 74°30' N 7°53' W	8.15 p. m.	0	638	0.0			
		8.20 -	5	-	0.1	18.095	32.69	26.26
		8.25 -	10	-	0.0?	.065?	.64?	.23
		8.30 -	15	-	-0.3?	.41?	33.26?	.74
		8.35 -	20	-	-0.4?	.435?	.31?	.78
		8.40 -	25	-	-0.5?	.57?	.55?	.98
	July 12	2.44 a. m.	50	Z 20	-0.89	19.225	34.73	.95
	July 11	9.4 p. m.	60	-	-0.21	.30	.87	28.03
	July 12	2.26 a. m.	80	-	-0.59	.305	.88	.06
	July 11	9.18 p. m.	100	-	-0.58	.335	.93	.10
		9.34 -	150	-	-0.61	.325	.91	.08
		9.52 -	200	-	-0.96	.325	.91	.10
		10.19 -	300	-	-0.97	.325	.91	.10
		10.38 -	400	-	-1.04	.345?	.95?	.13?
		11.01 -	500	-	-1.14	.335	.93	.12
		11.26 -	700	-	-1.18	.33	.92	.12
		11.54 -	1000	-	-1.24	.33	.92	.12
	July 12	0.49 a. m.	1500	-	-1.32	.33	.92	.12
		1.36 -	2000	-	-1.34	.32	.90	.11

¹ An other series of water-samples (from 1-40 metres) was taken near this Station on July 11, between 6.0 and 6.30 a. m. The determinations of Specific Gravity and Chlorine are given on p. 10. ² The Negretti and Zambra Reversing Thermometer No. 72012 (Z 12) has obviously given irregular and much too high readings on this day.

Station	Date and Locality	Hour	Depth in Metres	Designation of Thermometer	Corr. Temperature <i>in situ</i>	Chlorine Cl ‰	Salinity S ‰	Density <i>in situ</i>
24	1901		M.		° C.	‰	‰	σ_t
	Aug. 20	9:11 a. m.	0	638	1.3	18.10	32.70	26.20
	23 naut. miles SE ^b E	11:50 -	0	-	1.7	.28	33.03	.45
	from Cape Mohn	10:35 -	5	-	1.3	.685	.76	27.05
	(Northeast Land, Spitsbergen).	10:30 -	10	-	1.2	.72	.82	.11
		10:25 -	15	-	0.0	.86	34.07	.38
		10:20 -	20	-	0.2	.885	.12	.40
		1.0 p. m.	-	Z 20	0.30	.86	.07	.36
		10:15 a. m.	25	638	0.4	.865	.08	.36
		0.45 p. m.	-	Z 20	-1.16	.975	.28	.60
		0.28 -	30	-	-1.44	.96	.25	.58
		0.16 -	40	-	-1.63	19.055	.43	.72
		11:58 a. m.	60	-	-1.94	.095	.50	.79
		11:42 -	80	-	-1.92	.09	.49	.78
		9:55 -	100	-	-1.80	.115	.53	.82
		9:39 -	125	-	-1.51	.145	.59	.85
		9:11 -	150	-	-1.79	.155	.61	.88
			164	-	-	-	-	-
25	Aug. 27	7:10 p. m.	0	638	1.3	18.65	33.69	26.99
	8 miles south of C. Altmann, King Charles Land	5:35 -	25	Z 20	0.13	.79	.95	27.27
		5:48 -	30	-	-0.63	.805	.97	.33
		6:04 -	50	-	-1.17	.935	34.21	.54
		6:18 -	60	-	-1.17	.99	.31	.62
		6:34 -	80	-	-1.25	19.025	.37	.67
		6:52 -	100	-	-1.35	18.99	.31	.63
		7:08 -	110	-	-1.36	19.01	.34	.66
			120	-	-	-	-	-

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The Surface Map is based on the observations of Capt. Roald Amundsen, the Capella, Hvidfisken, Jassai, and Dr. Knipowitsch in June and July, 1901.

The Maps for 50-400 Metres are based on the observations of the many expeditions of different years.

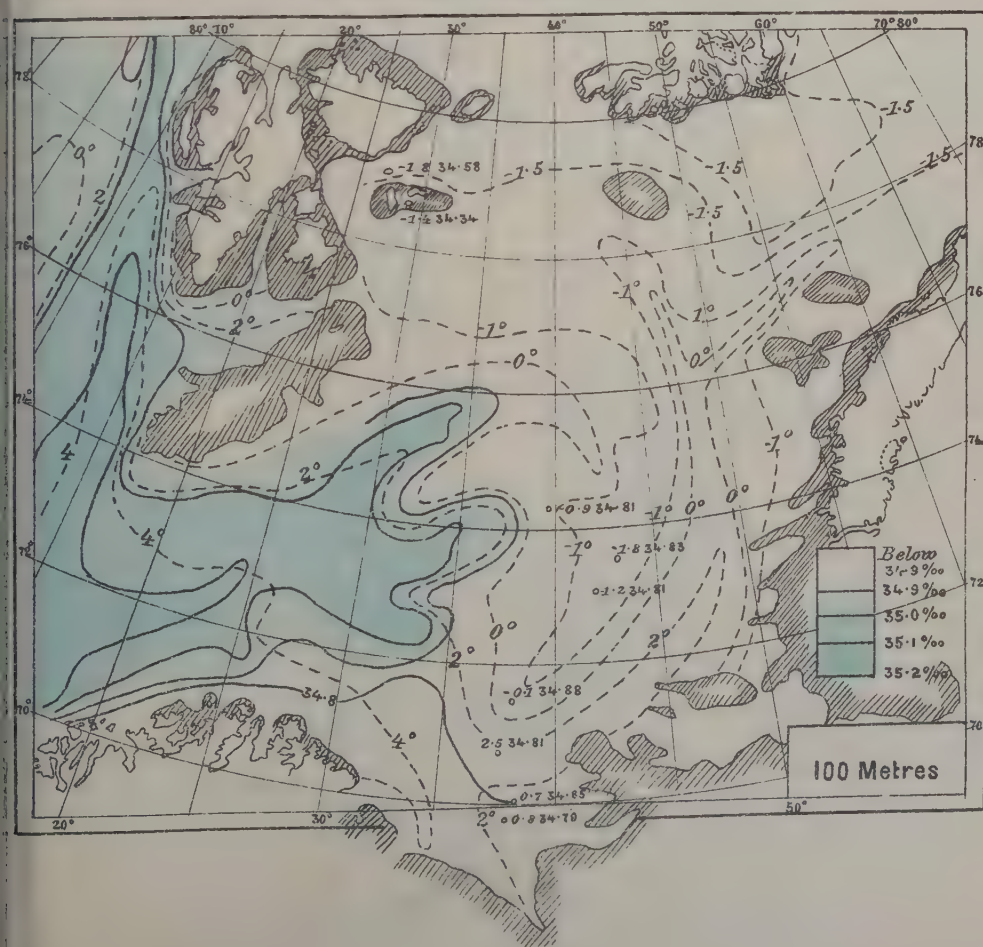
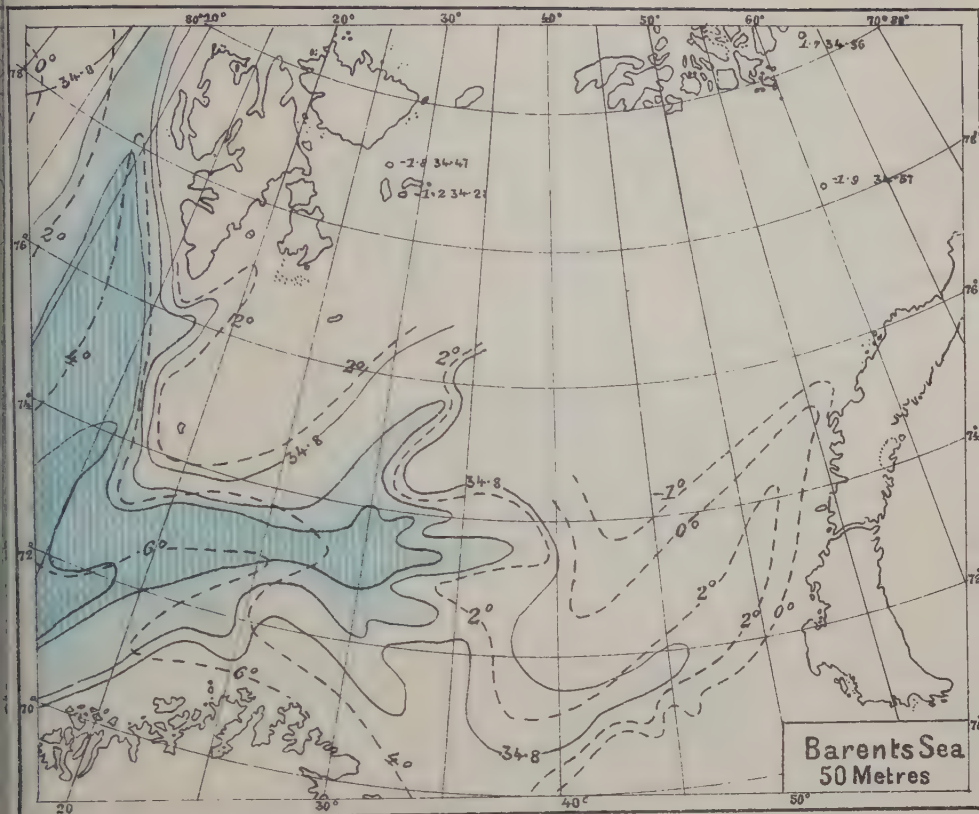
Stations.

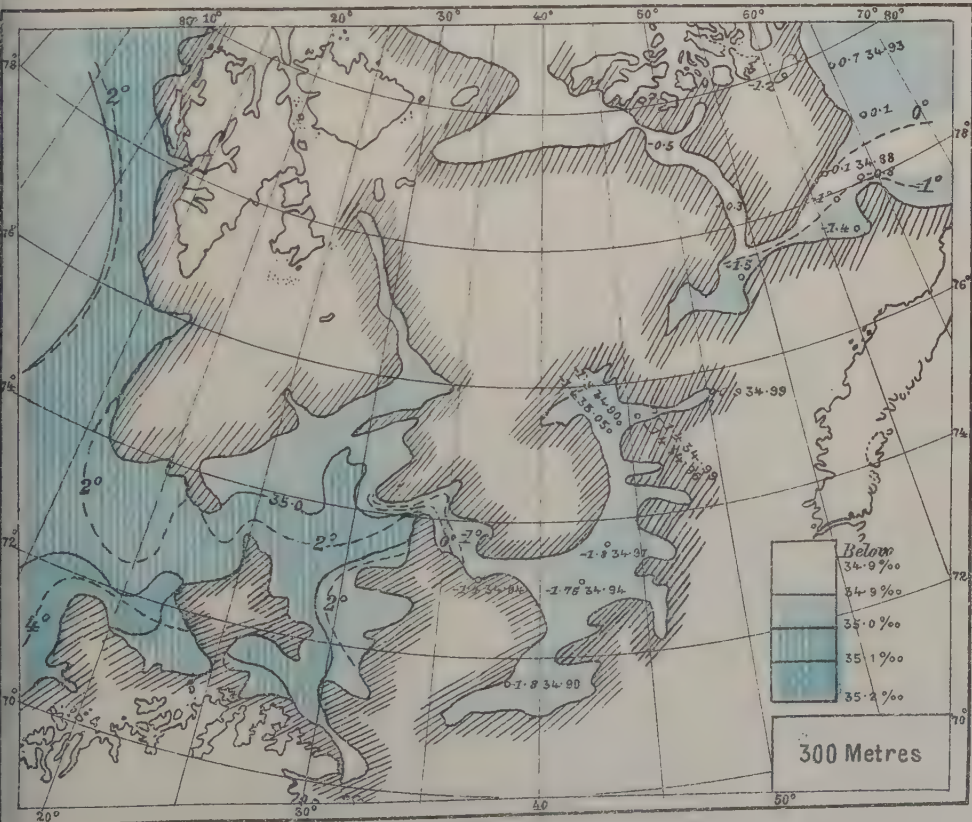
- A 13 - A 23 Amundsen June-Aug. 1901
- MS 9 - MS 68 The „Michael Sars“ July-Sept. 1900
- MS 14 - MS 28 off northern Norway, The „Michael Sars“ Febr.-March 1901
- MS 68 - MS 94 The „Michael Sars“ June-July 1901
- MS 7A - MS 12A The „Michael Sars“ February 1903
- M 206 - M 215 Mohn July 1877
- M 277 - M 370 Mohn July-Aug. 1878
- R II - R XVI Ryder June-July 1891
- R XXVI - R XXVII Ryder Aug. 1892
- Ar I - Ar X Arrhenius Aug. 1896
- N VI - N X Nathorst (Åkerblom) June-July 1899
- F I - F II Kolthoff with the Frithjof (Østergren) July 1900
- Ap II - Ap IV Amdrup June-July 1900
- Ma V - Ma X Makaroff June 1899
- Ma XV - Ma XXXI Makaroff Aug. 1899
- K 106 - K 111 Knipowitsch Oct. 1901 and Breitfuss Oct. 1902
- 500 - 509 Knipowitsch July 1901
- B 70 - B 76 Breitfuss Aug. 1902

Below 34.9‰
34.9‰
35.0‰
35.1‰
35.2‰
Above 35.2‰

Scale 1:12000000

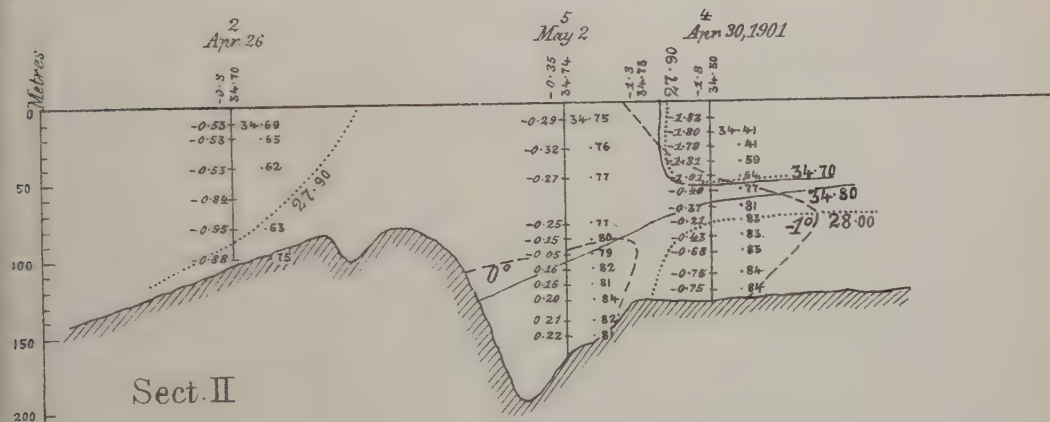




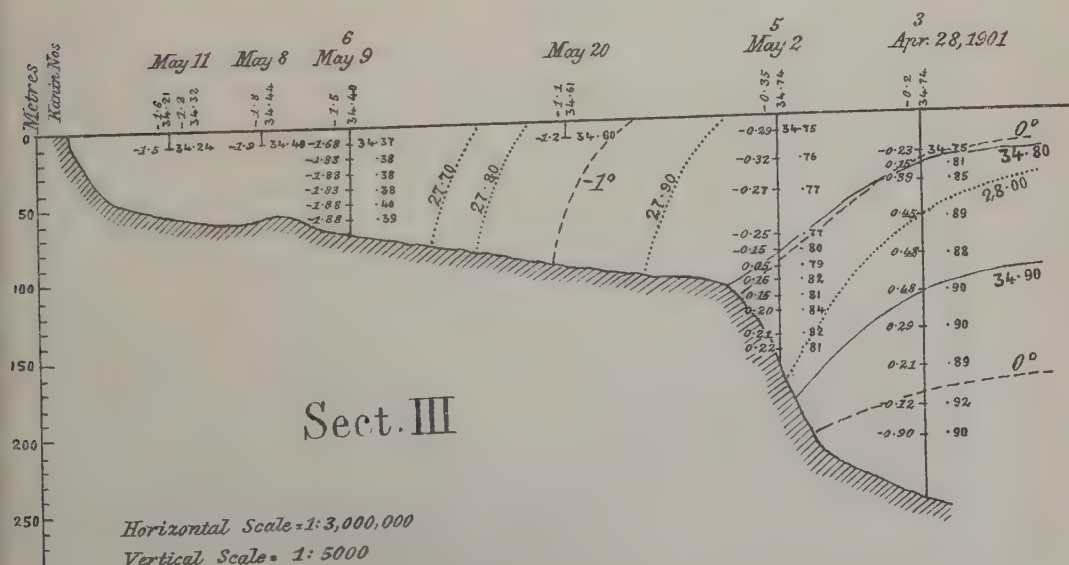




Sect. I



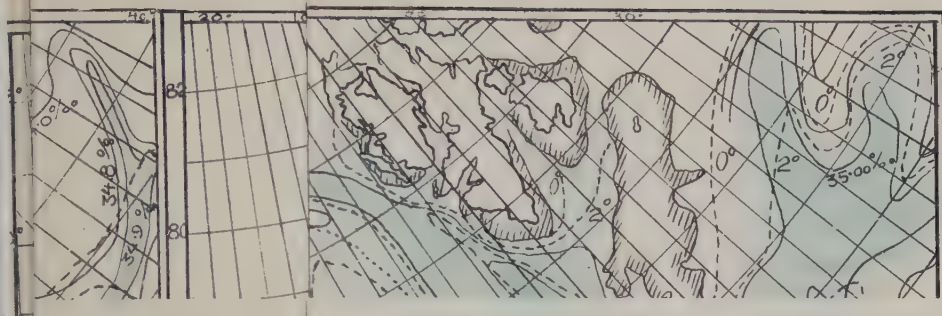
Sect. II



Sect. III

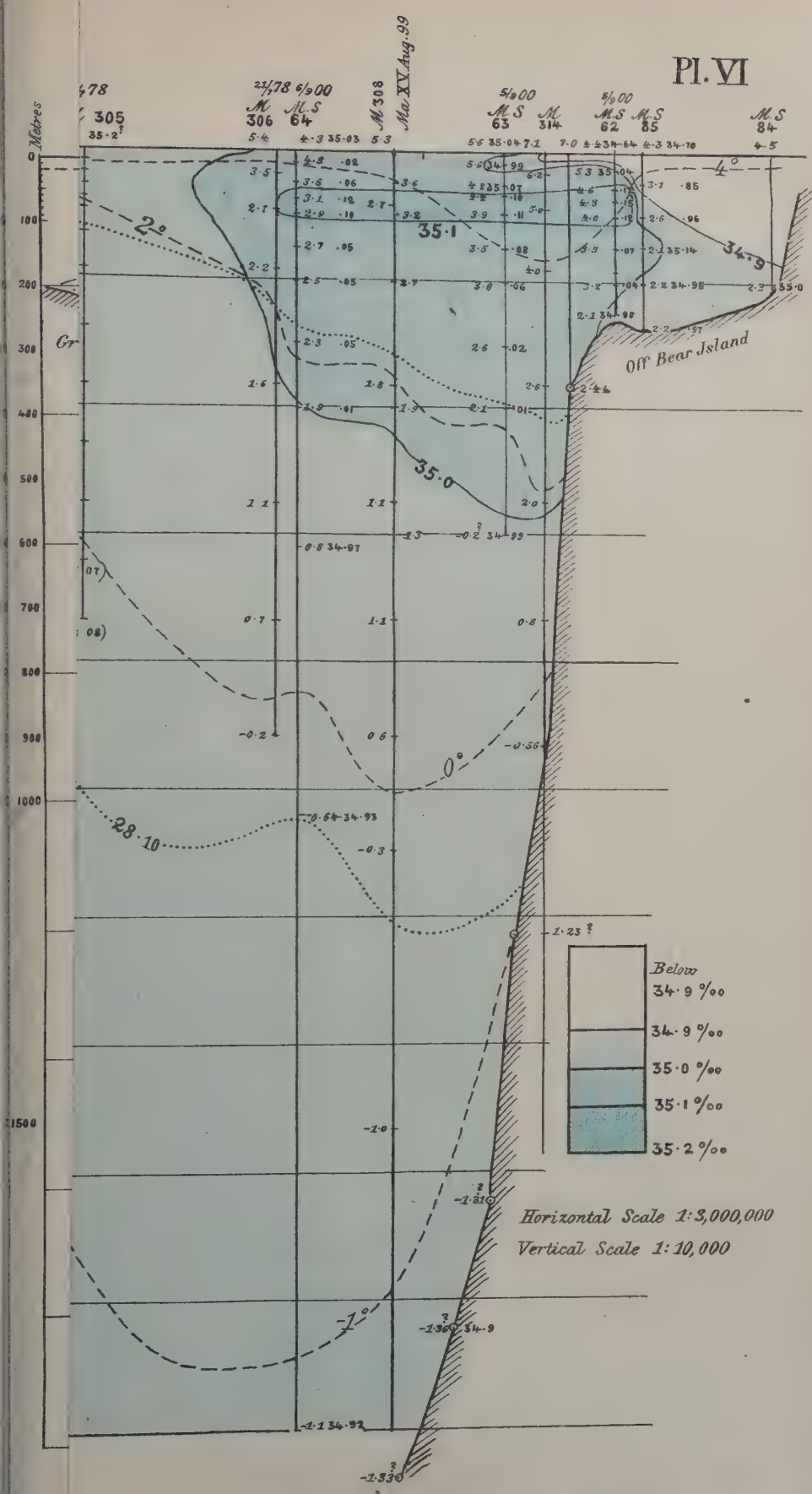
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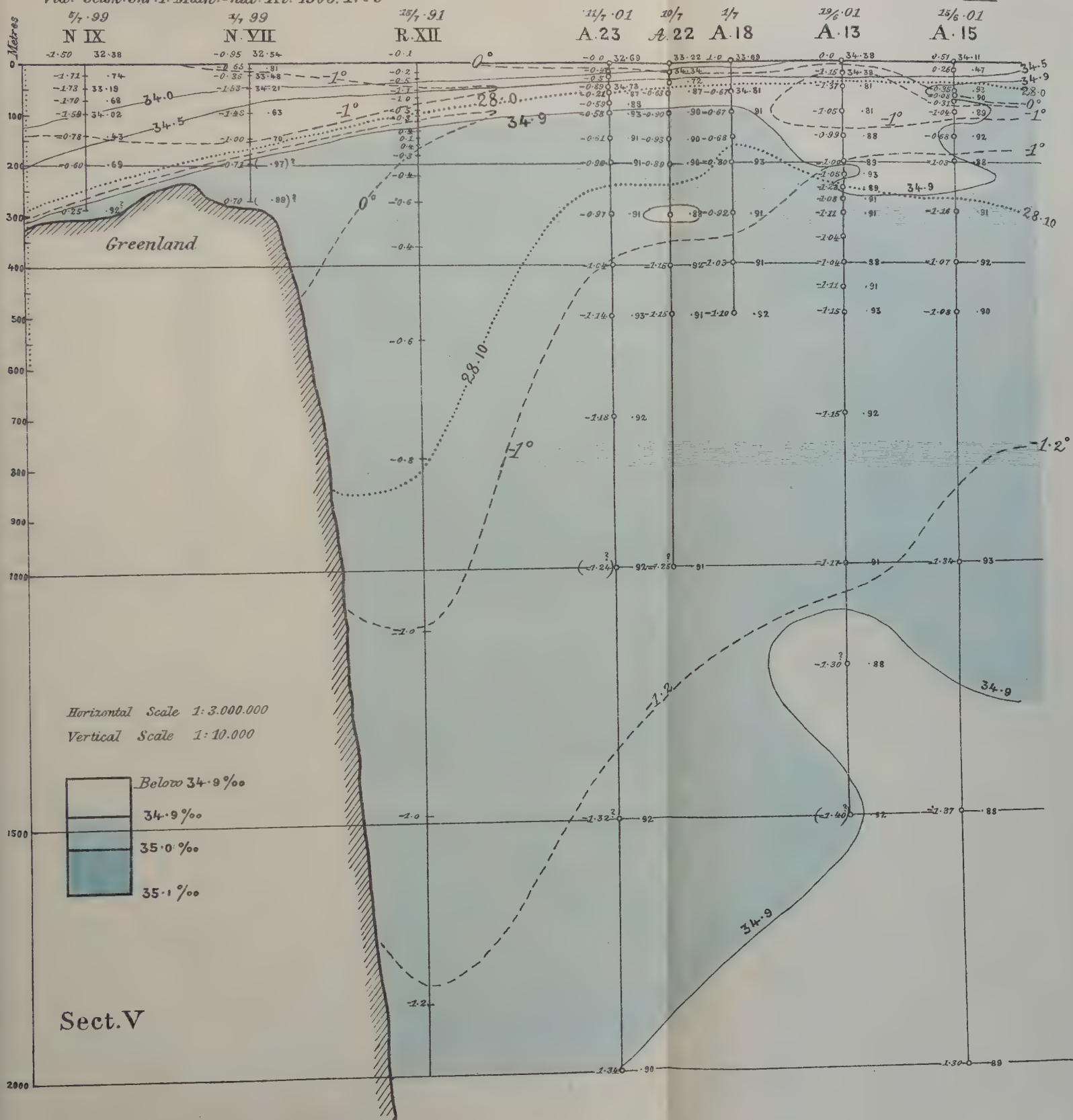
PL.V



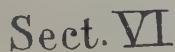


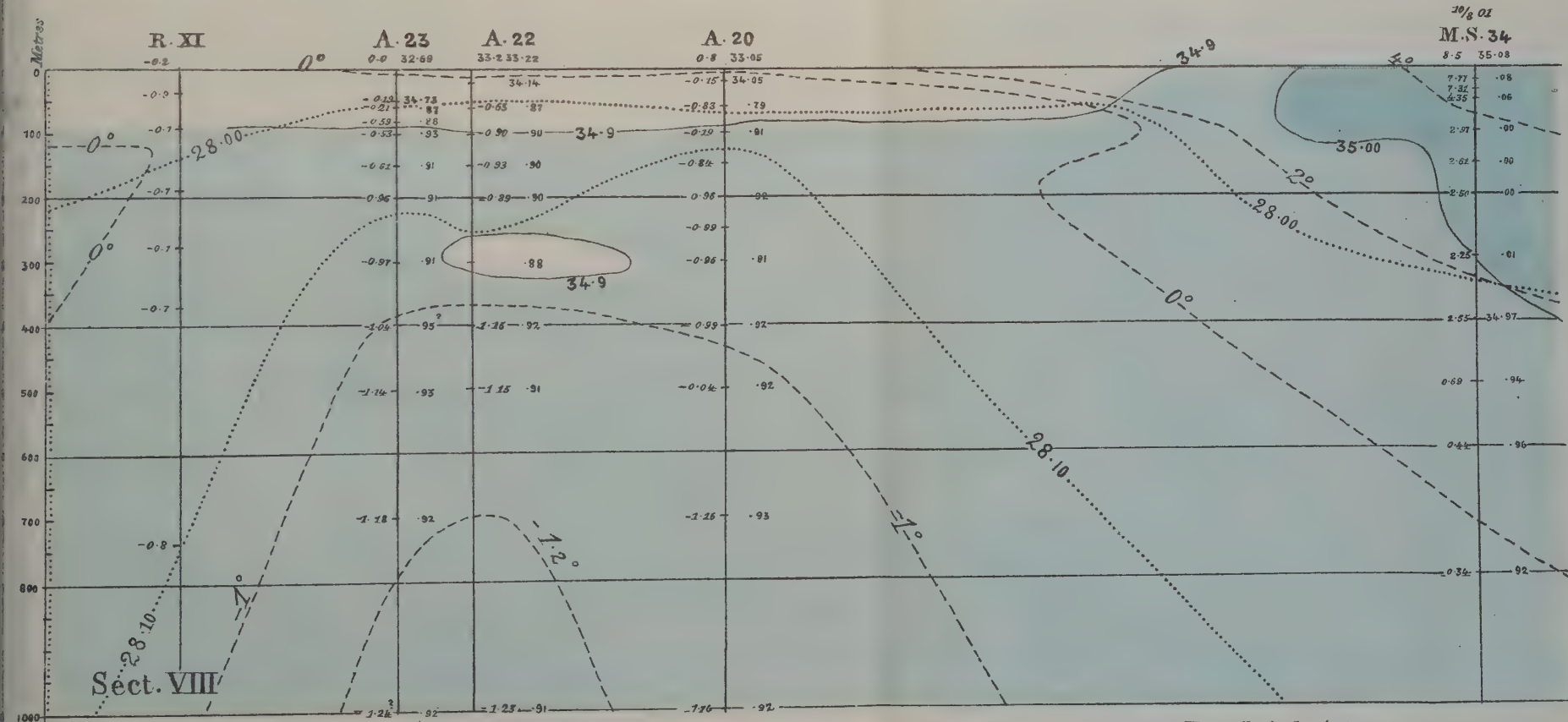
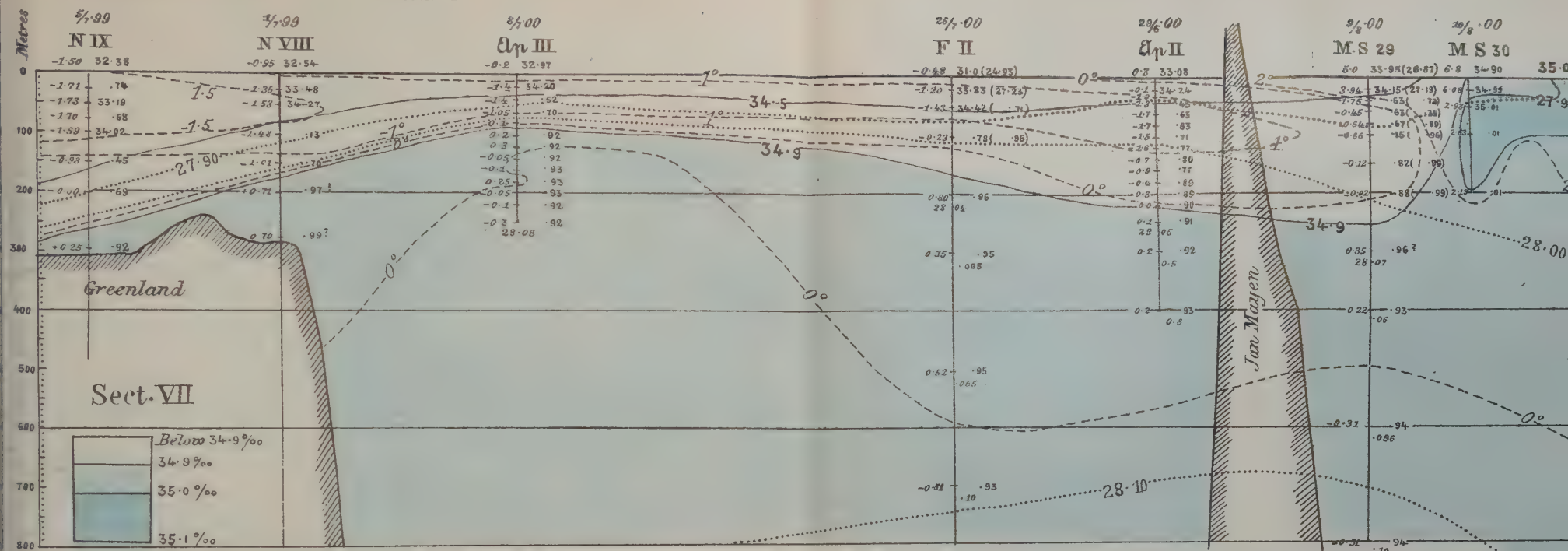
Pl. VI



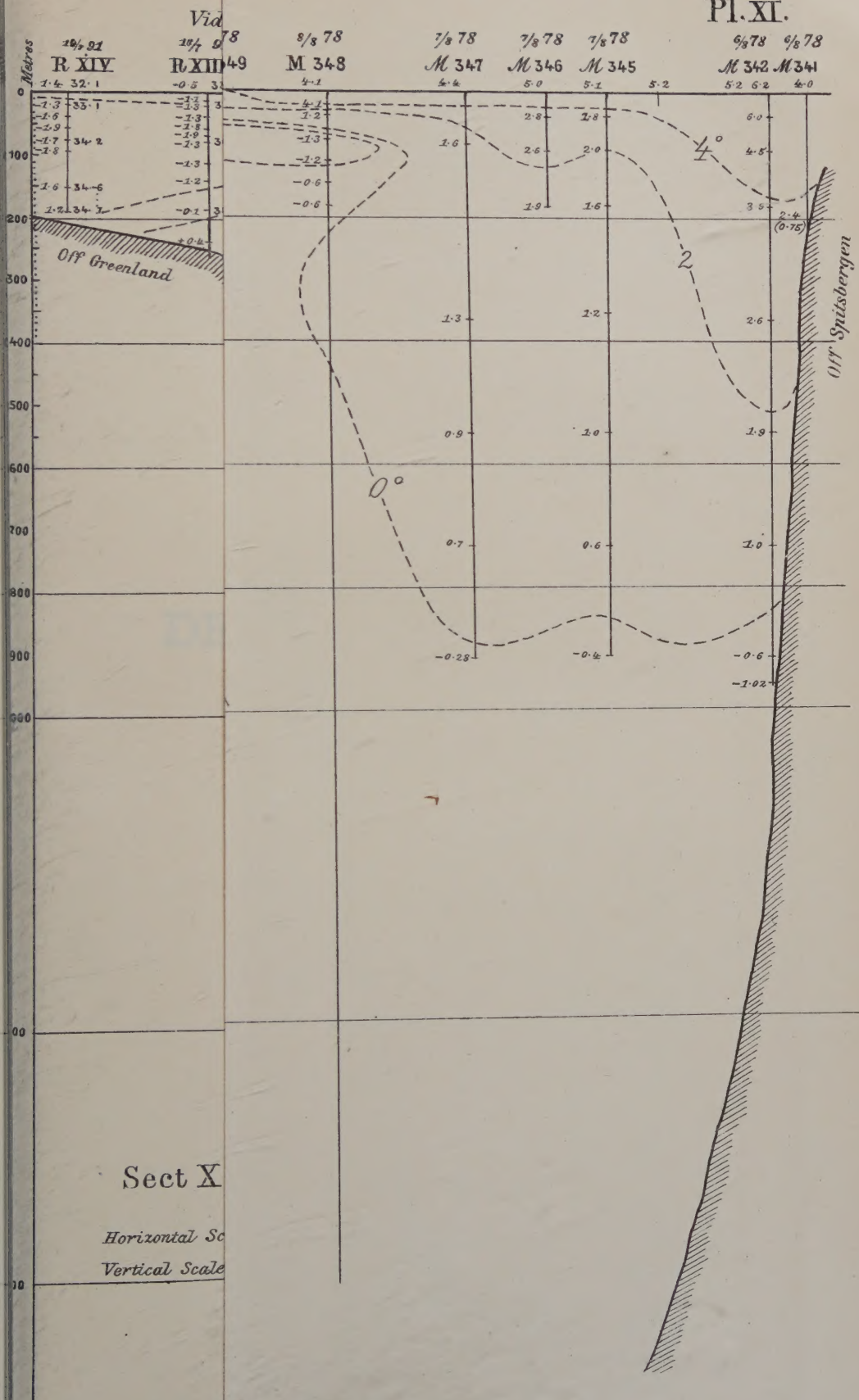


M. 300





Horizontal Scale 1:3,000,000. Vertical Scale 1:10,000



ANDEN DEL.

DEN ÆLDRE KEMI.
